Preliminary Drainage Report

Plambeck Gardens

23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon 97062

Date:
February 25, 2022
Revised:
May 2, 2022

Owner:
Community Partners for Affordable Housing
6380 SW Capitol Highway #151
Portland, OR 97239

Prepared by: Brynne Healy
Engineer of Record:
Alex Wesolovski, PE
Vega Civil Engineering, LLC
1300 SE Stark St #201
Portland, OR 97214
alex@vegacivil.com
(503)662-1901

ALEXANDER F WESOLOVSKI
SEPT 23, 2019
EXPIRES: 6/30/2022

Table of Contents

Tables

Appendices

Project Overview and Description

Location	23500 & 23550 SW Boones Ferry Road Tualatin, Oregon 97062
Site Area	203,082 sf (4.66 acres)
Vicinity Map	
Zoning	RH Zone – High Density Residential
Existing Conditions	The site consists of two single family houses and various structures connected by gravel driveways.
Existing Drainage	Site Topography: The existing grades of the site range from ±3% to ±7% with the highest elevation of ±357 feet along the northeastern portion of the site and the lowest elevation of ± 330 feet along the northwestern portion of the site near SW Boones Ferry Road. Soil Type: The existing underlying geology was identified as the Sentinel Bluffs Member (Tgsb). Missoula floods deposited were also identified on site and consist of unconsolidated stratified clay, silt, sand, and gravel. Surface soils were identified by the US Soil Survey as Unit 28B: Laurelwood silt loam. Site Drainage: Currently, onsite stormwater is directed to catch basins on SW Boones Ferry Road on the northwestern and southwestern portions of the site. Water is then gravity fed to nearby streams.

Development Description	Two new 4-story multi-family residential buildings and a new 1-story community building. Parking improvements include a new parking lot and three new 1-story garage structures. Site improvements include two new trash enclosures, play structures, picnic shelters, sport court, play field, and community gardens.

Jurisdictional Requirements

Water Quantity	Per CWS and R&O 19-05 standards as outlined in section 4.02, Water Quantity Control Requirements for Conveyance Capacity, “each new development shall incorporate techniques for mitigating its impacts on the public stormwater system in accordance with Section 5.05.”.
Hydromodification	Per Clean Water Services (CWS) Design and Construction Standards Manual for Sanitary Sewer and Surface Water Management (R&O 19-05) standards as outlined in section 4.03, Hydromodification Approach Requirements, and Table 4-2, the project site is identified as Category 3. Therefore, the CWS hydromodifications requirements will be met by providing peak-flow matching detention and LIDA. Peak-Flow Matching Detention using design criteria described in Section 4.08.6 and management of runoff from 30% of the impervious area using any LIDA in Table 4-3, sized in accordance with Section 4.08.4.b, and described in section 4.09, will be used.
Water Quality	Per CWS and R&O 19-05 standards, stormwater quality approaches shall be designed to remove 65 percent of the total phosphorus from the runoff from the impervious area that is tributary to the facility. This criteria will be applied to ½ of the 2-yr, 24-hr storm event to meet the Department of Housing and Urban Development (HUD) requirements as well.

Design Methodology

Computation Methods & Software	HydroCAD software was used to develop the Santa Barbara Urban Hydrograph (SBUH), Type 1A storm for the peak-flow matching detention and water quality design, in accordance with Table 4-7 of the CWS standards to analyze the stormwater runoff from the project site.
Relevant Design Storms	Water Quality Treatment Storm, CWS – 0.36 inches in 4 hours with average return period of 96 hours. Water Quality Treatment Storm, HUD – 1.25 inches, 24hrs 2-yr – 2.50 inches, 24hrs (CWS, HUD) 5-yr – 3.10 inches, 24hrs (CWS, HUD) 10yr – 3.45 inches, 24hrs (CWS, HUD) 25yr – 3.90 inches, 24hrs

Infiltration Testing Results	Due to poor infiltration rates along most of the eastern portion of the site and groundwater being encountered at 4 – 7.5 feet below grade, infiltration was not considered as a reasonable means of stormwater mitigation.
Proposed Stormwater Management System	The proposed stormwater management consists of two stormwater basins (one with CUDO detention cubes below grade) in the northwestern and southwestern portions of the site. The north basin will manage a total of 119,142 SF of combined impervious and pervious area, while the south basin will manage a total of 89,933 SF. Additional impervious area in the ROW not directed to the basins will be accounted for by oversizing the facilities to meet predeveloped flow rates. See Table 1 and Catchment Map, Appendix A. All roof and area drains will collect stormwater from new impervious surfaces created and be directed to the stormwater basins, which are sized to manage the CWS and HUD water quality storm events. The basins, with the addition of CUDO detention cubes, will provide storage to manage flow rates. The basins will then connect to an MH with orifice flow control, and will discharge to the public system in SW Boones Ferry Rd. The north basin will connect to an existing stormwater inlet in the ROW. The south basin will connect to a proposed stormwater main extension which will tie into the existing system to the south of the project site.

Analysis

Curve Numbers	A curve number (CN) of 98 was used for newly constructed impervious areas on site. A pre-developed adjusted CN of 69 was used as recommended for the SBUH for sites with over 75% grass cover and soil groups B. It was then adjusted to 70 and 72 for the North and South basins, respectively, to account for differing areas of gravel/ farrow soil present in each basin. See Appendix D for the TR55 runoff curve number table.
Time of Concentration	10 minutes was used for the time of concentration for all post-developed basins. 34.6 minutes was used for the time of concentration for the pre-developed, southern portion of the site. 28.1 minutes was used for the time of concentration for the pre-developed, northern portion of the site.
Water Quantity	Flow control for the proposed project will utilize a combination of stormwater basins, CUDO detention cubes, and orifice flow control to limit the post-development peak flow rates to the allowable pre-development peak flows for each storm event. For driveway and ROW sidewalk area that cannot be directly managed by the stormwater facilities, the additional runoff will be accounted for by oversizing the facility to continue meeting pre-developed rates. See Table 2.
Hydromodification	The proposed project will generate approx. 124,981 SF of proposed impervious area. Per CWS Category 3, the site will provide peak-flow matching detention (see Table 2) and will utilize vegetated stormwater basins to meet LIDA requirements.
Water Quality	Water Quality for the proposed project will be provided via two stormwater basins designs to CWS and HUD standards. They have been sized to treat impervious area runoff from the proposed project. See Appendix B for Water Quality Calculations.

Table 1 – Catchment and Facility Summary-Water Quantity

Catchment or Facility ID	Area Type	Area (sf)	Facility 1	Facility Size	Facility 2	Facility Size
North (8S)	Roof/Parking/Sidewalk	63,615	Stormwater Basin	2200 sf (bottom area)	CUDO storage	555 2x2 units
	Pervious/Landscape	51,060				
	Unmanaged Impervious	4,467	N/A			
South (9S)	Roof/Parking/Sidewalk	61,366	Stormwater Basin	2016 sf (bottom area)	N/A	N/A
	Pervious/Landscape	37,309				
	Unmanaged Impervious	1,258	N/A			
TOTAL		209,075				

Table 2 – Pre vs. Post Construction Flow Rates

Catchment or Facility ID	Peak Flow Rate (cfs)							
	2 yr		5 yr		10 yr		25 yr	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
North (8S)	0.07	0.06	0.16	0.16	0.24	0.23	0.35	0.30
South (9S)	0.11	0.05	0.24	0.17	0.32	0.22	0.45	0.32
TOTAL	0.18	0.11	0.40	0.33	0.56	0.45	0.80	0.62

Engineering Conclusions

Water Quantity	In addition to stormwater basins, CUDOs detention cubes (North basin) with orifice flow control will be utilized below the finished grade of the basins to manage stormwater quantity, per CWS standards. Runoff from area and roof drains throughout the site will be directed to the basins before entering the detention cubes and being transported to the City storm system on Boones Ferry Road. All water quantity storm events are meeting management requirements, except for the 2-yr, 24hr storm event at the North basin due to the minimum orifice size requirement of ½ inch.
Hydromodification	Using the CWS Hydromod Planning Tool, the project site is located within an expansion area and drains to a high-risk level exiting stream. The project site is over 80,000 square feet, classifying it as Large project. Based on the parameters mentioned above and in Table 4-2 from the CWS Design and Construction Standards, the project site is within Category 3 for the Hydromodification Approach. As a requirement for Category 3 projects, the site will provide peak-flow matching detention, using criteria from sections 4.08.6 of the CWS Design and Construction Standards. Specifically, the post-developed 5 and 10 year, 24 hour storm peak runoff rate will match the pre-developed 5 and 10 year, 24 hour storm peak runoff rate and the post-developed 2 year, 24 hour storm peak runoff rate will not exceed more than 50% of the pre-developed 2 year, 24 hour storm peak runoff rate.
Water Quality	Per CWS Design and Construction Standards, Chapter 4, the proposed stormwater quality basins are designed to remove 65 percent of the total phosphorus from runoff of a storm event totaling 0.96 inches of precipitation falling in four hours with an average return period of 96 hours from newly constructed impervious surfaces. This approach was then applied to ½-2yr, 24hr storm event to meet HUD water quality requirements.
Conveyance	Calculations have been performed using HydroCAD to determine the stormwater conveyance design for the development based on CWS standards, which require a minimum 10-inch pipe size for the runoff based on a 25-year storm event.

Upstream / Downstream Impacts

The on-site stormwater system meets the high-risk design requirements via on-site detention and flow control for all of the required predeveloped peak flow storm events. See Downstream Analysis (Appendix E) for exhibits and calculations.

Northern Basin

Stormwater runoff will be conveyed to an existing Boones Ferry Road stormwater system catch basin through a 10” stormwater pipe connection. Runoff will flow approximately 315 feet north through the downstream 12” public stormwater main to a maintenance hole, which serves a portion of the remaining drainage basin prior to the discharge point via an 18” main. It discharges to a drainageway, flowing approximately 1,400 feet to Tapman Creek. During the 25-year storm event, the 12” and 18” mains are at 6% and 28% capacity, respectively. At the point of discharge to the drainageway, the site represents 2.9% of the total tributary drainage flow during the 25-year storm event.

A quarter-mile downstream visual study was performed confirming there are no downstream obstructions.

There are no facilities upstream of the north basin.

Southern Basin

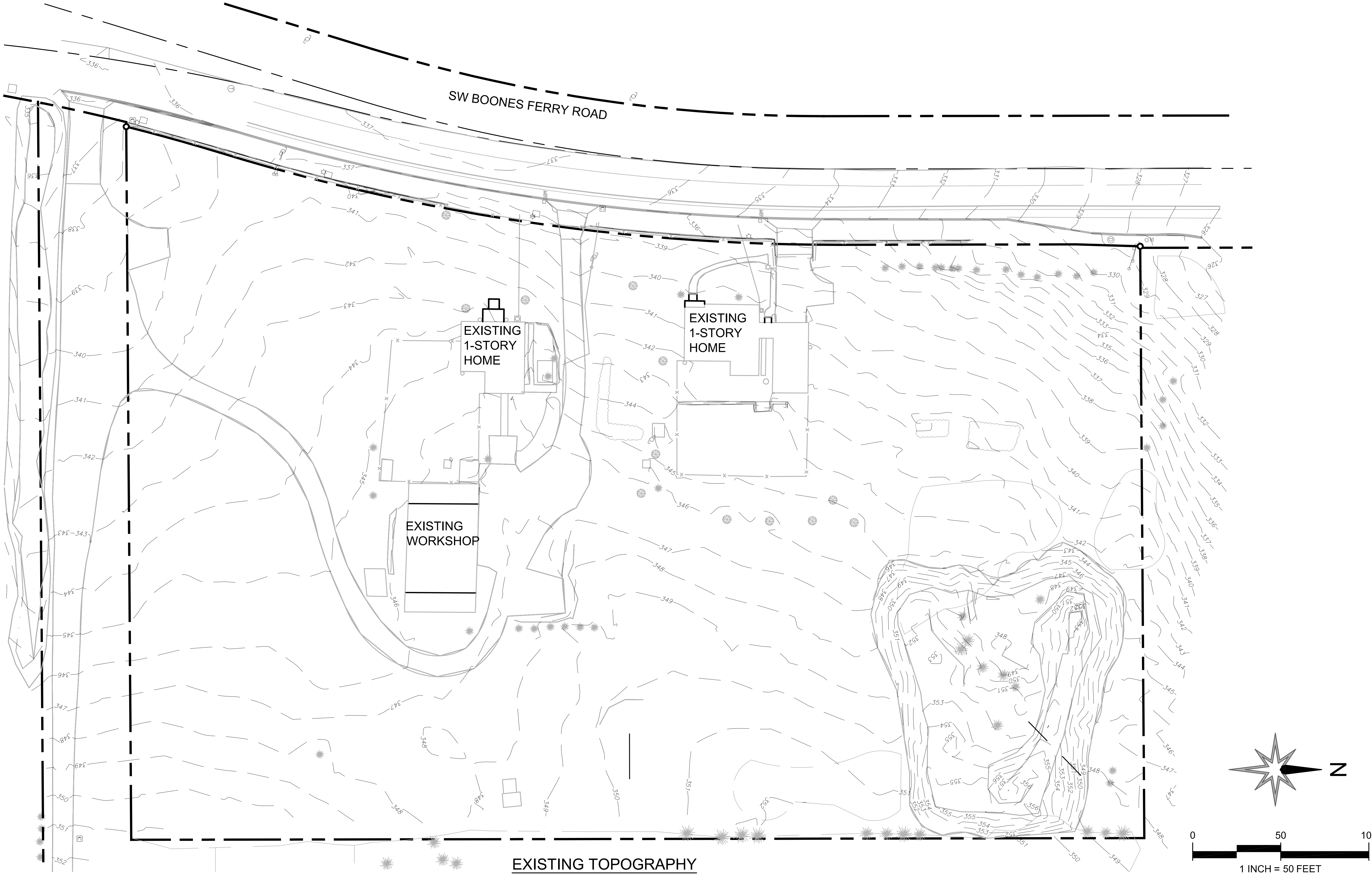
Stormwater runoff will be directed through a 10” stormwater pipe to the existing 12” stormwater system within Boones Ferry Road. It will flow approximately 750 feet south to a maintenance hole, which serves a portion of the remaining drainage basin prior to the discharge point. The downstream stormwater system then continues as a 15”, which ultimately serves as the discharge point to a drainageway serving Tapman Creek. The drainageway is approximately 570 feet long. During the 25-year storm event, the 12” and 15” stormwater mains will be at 19% and 23% capacity, respectively. At the discharge point to the drainageway, runoff from the site represents 1.2% of the total tributary drainage flow during the 25-year storm event.

A quarter-mile downstream visual study was performed confirming there are no downstream obstructions.

There are no facilities upstream of the south basin.

Appendix A: Stormwater Facility Details / Exhibits

Existing Topography
Existing Ground Cover Site Map
Proposed Topography
Stormwater Plans
Catchment Map
Stormwater Facility Details



EXISTING TOPOGRAPHY

SITE TOTAL AREAS

🟦 GRAVEL = 11,003 SF

🟨 PAVING = 1,072 SF

🟥 ROOF = 7,145 SF

🟩 LANDSCAPE = 188,622 SF

TOTAL = 207,842 SF

NORTH BASIN

🟦 GRAVEL = 860 SF

🟨 PAVING = 450 SF

🟥 ROOF = 2,422 SF

🟩 LANDSCAPE = 92,895 SF

TOTAL = 96,627 SF

SOUTH BASIN

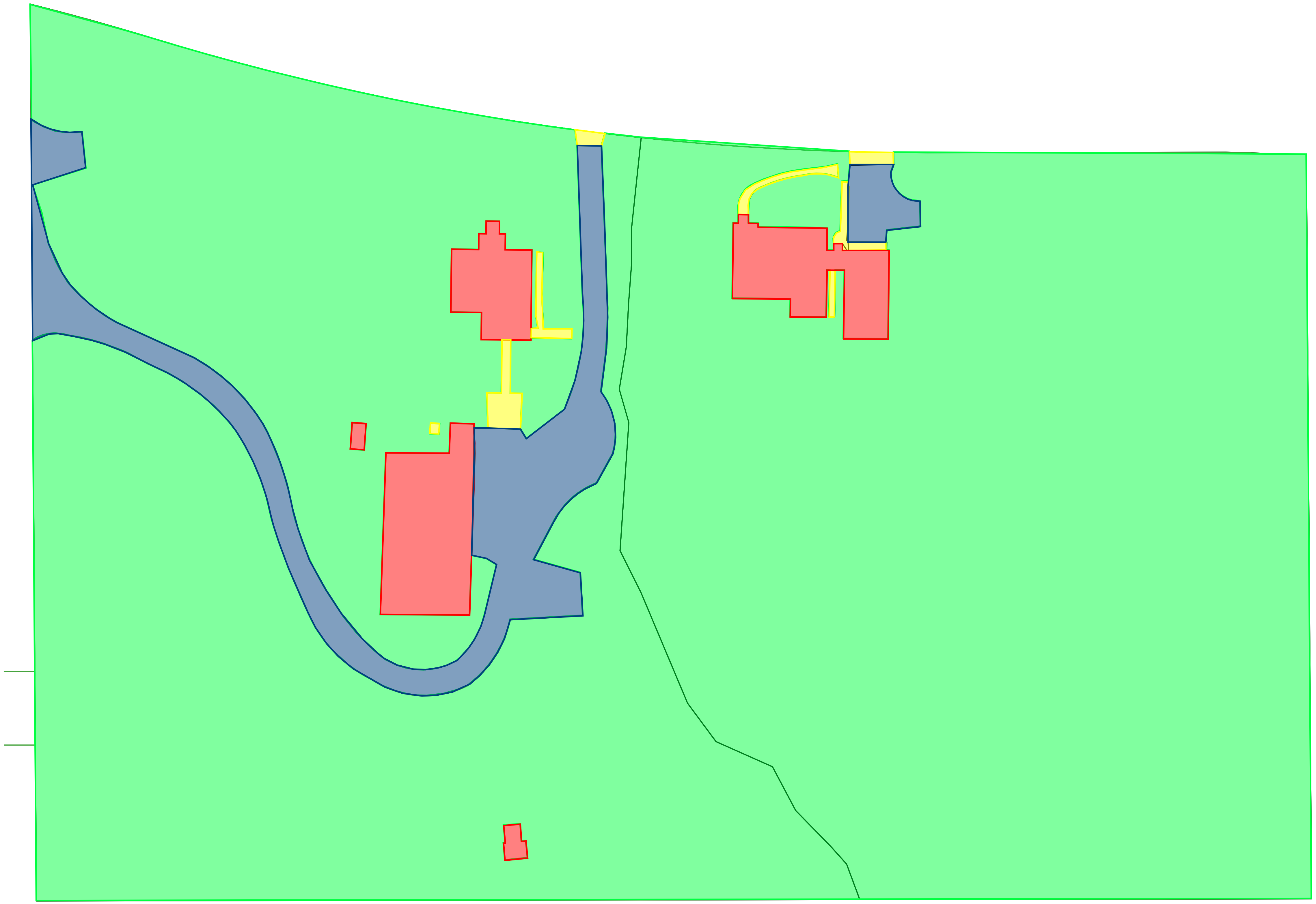
🟦 GRAVEL = 10,143 SF

🟨 PAVING = 622 SF

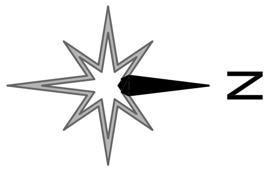
🟥 ROOF = 4,723 SF

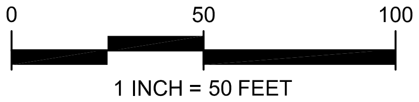
🟩 LANDSCAPE = 95,727 SF

TOTAL = 111,215 SF

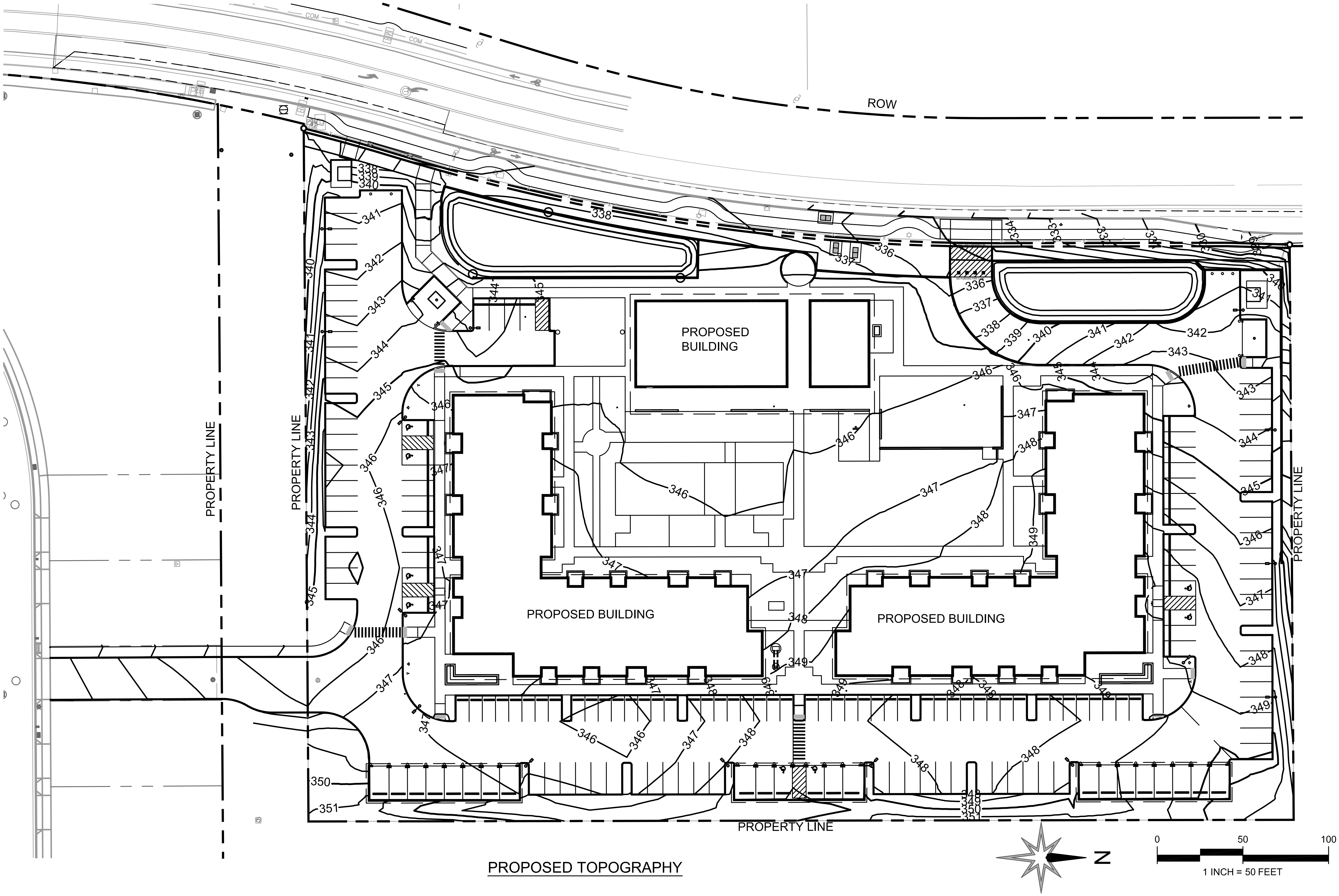


EXISTING GROUND COVER SITE MAP

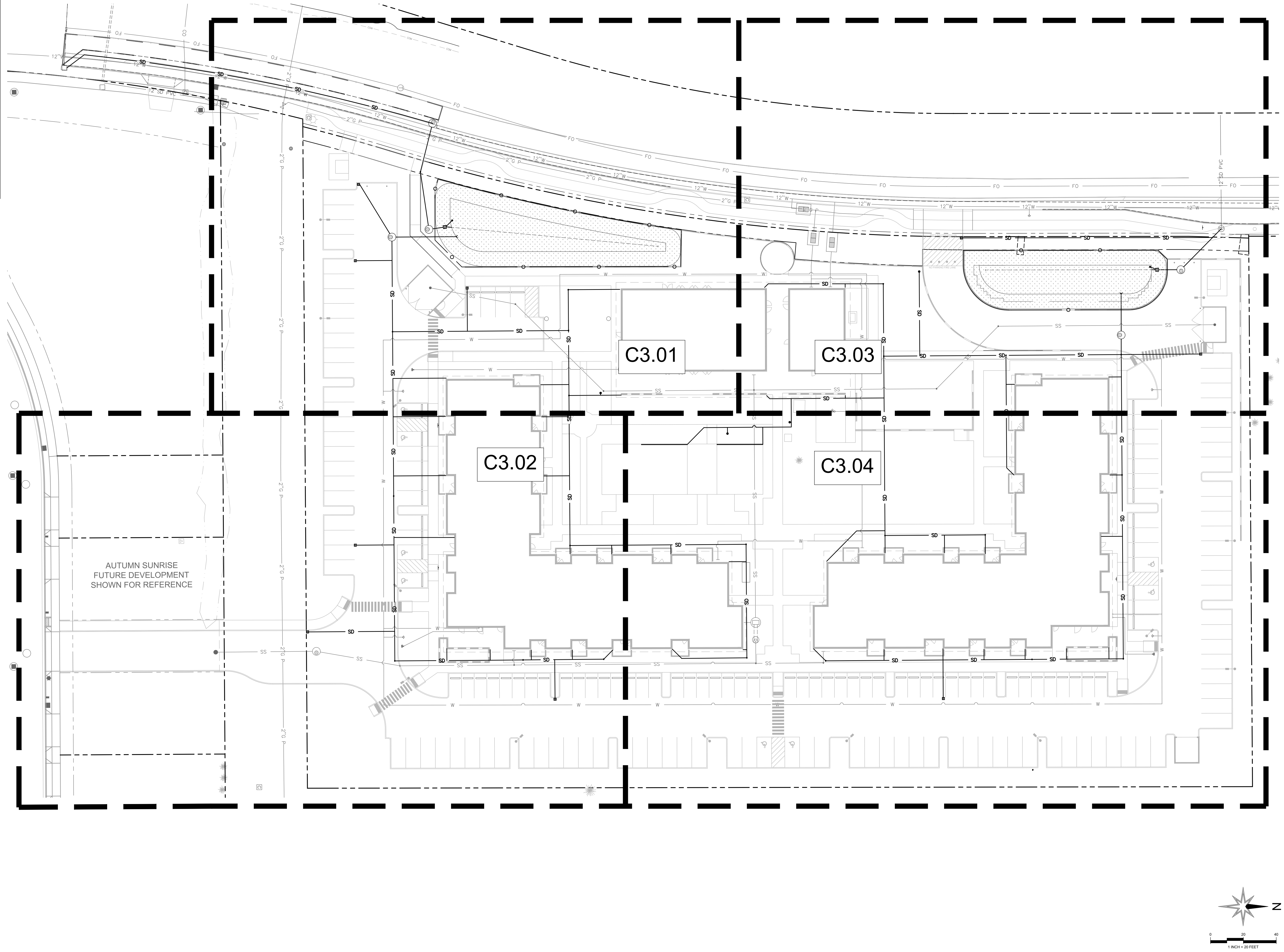




VEGA
CIVIL ENGINEERING LLC
503.662.1901 | WWW.VEGACIVIL.COM



PROPOSED TOPOGRAPHY



PRELIMINARY
NOT FOR
CONSTRUCTION

CARLETON HART ARCHITECTURE P.C.
830 sw 10th avenue #200 portland oregon 97205
503.243.2252 | www.carletonhart.com

VEGA
CIVIL ENGINEERING LLC
503.662.1901 | WWW.VEGACIVIL.COM

PLAMBECK GARDENS
COMMUNITY PARTNERS FOR AFFORDABLE HOUSING
23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon 97062

LAND USE: ARCHITECTURAL REVIEW

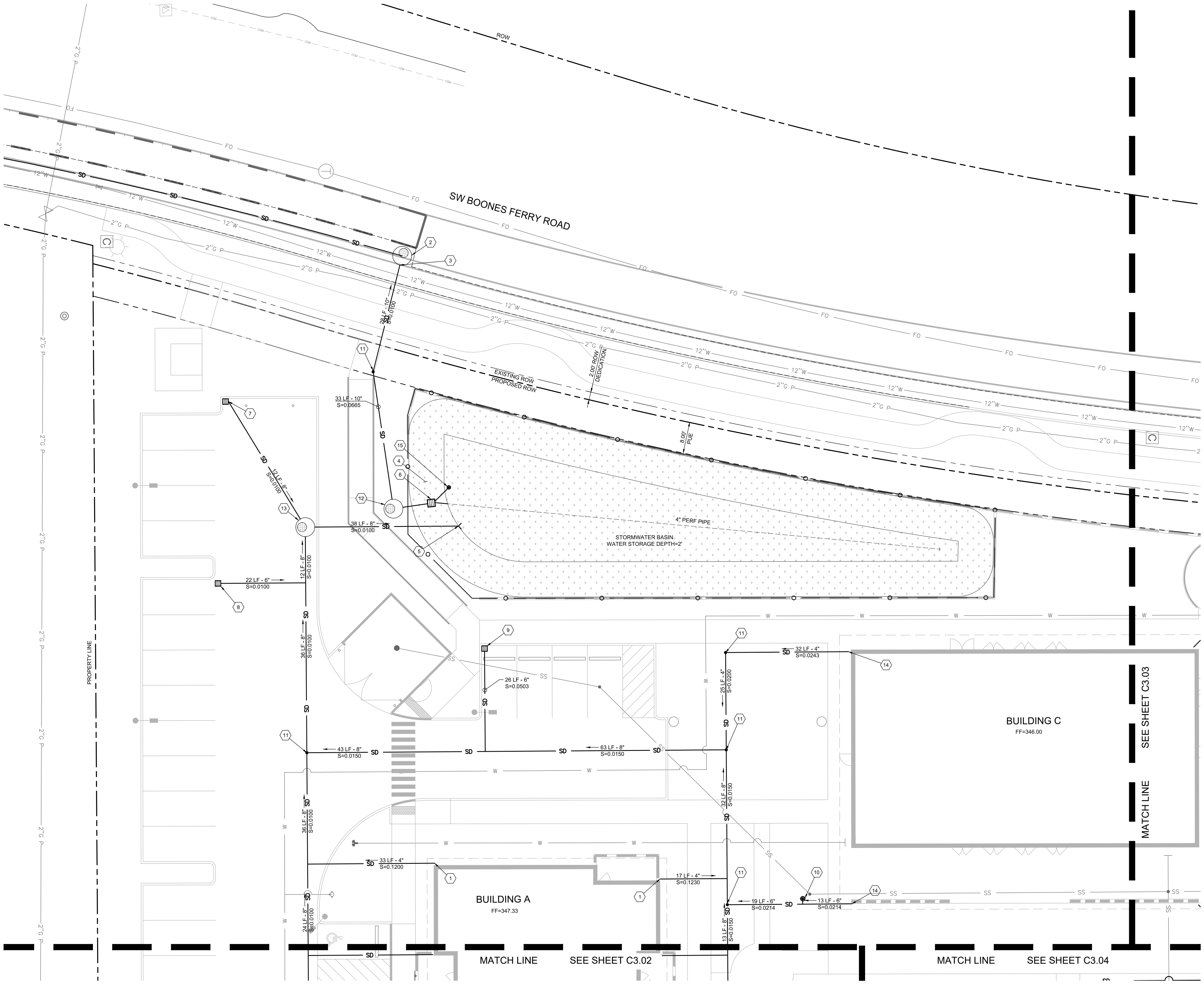
STORMWATER PLAN -
OVERALL

PROJECT NO.
#19031

03.04.2022

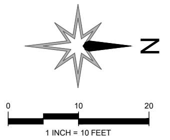
REVISIONS:

C3.00



STORMWATER PLAN - SOUTHWEST

SCALE: 1"=10'

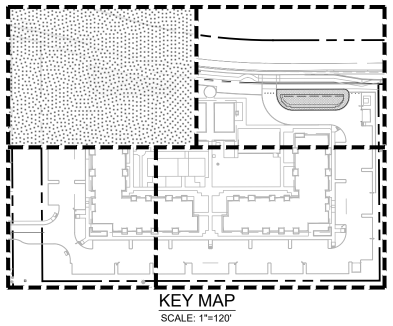


GENERAL NOTES

1. ALL WORK IN PUBLIC RIGHT-OF-WAY UNDER SEPARATE CITY OF TUALATIN PUBLIC WORKS PERMIT AND WASHINGTON COUNTY FACILITIES PERMIT. REFERENCE PUBLIC PLANS.
2. INSTALL "NO DUMPING / LEADS TO GROUNDWATER" MARKER AT ALL ONSITE CATCH BASINS PER DETAIL 11/C6.00.
3. FOR OTHER UTILITIES SEE SHEET C4.01.
4. COORDINATE ALL RETAINING WALL PENETRATIONS WITH STRUCTURAL.

STORMWATER NOTES

1. ROOF DRAIN CONNECTION FROM BUILDING A.
   IE=343.33
2. 48" STORMWATER MANHOLE AT CONNECTION TO NEW PUBLIC STORM MAIN, UNDER SEPARATE PUBLIC WORKS PERMIT. SEE C8.00 SHEETS.
3. STORMWATER CONNECTION TO PUBLIC MANHOLE.
   IE= 332.00
   RIM=336.40
4. STORMWATER BASIN PER DETAIL 8/C6.01
   AREA MANAGED=61,351 SF
   BOTTOM AREA=2,016 SF
   BOTTOM ELEVATION=338.17
   WATER STORAGE DEPTH=2.0'
5. OUTFALL TO STORMWATER BASIN.
   IE=338.17
6. DITCH INLET PER CWS STANDARD DRAWING NO. 390
   FLOW INVERT=340.00
   IE,IN=335.83
   IE,OUT=333.83
7. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=340.47
   IE=338.95
8. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=340.44
   IE=339.94
9. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=343.09
   IE=341.09
10. 12" DOMED LANDSCAPE AREA DRAIN PER DETAIL 3/C6.01
   RIM=345.75
   IE=342.75
11. STORMWATER CLEANOUT TO GRADE PER DETAIL 5/C6.01.
12. FLOW CONTROL MANHOLE PER CWS STANDARD DRAWING NO. 270.
   RIM=341.17
   10" OVERFLOW=339.71
   1" ORIFICE=333.47
   IE=333.47
13. WATER QUALITY MANHOLE PER CWS STANDARD DRAWINGS NO. 250 AND 260.
   RIM=340.42
   IE=338.58
14. ROOF DRAIN CONNECTION FROM BUILDING C.
   IE=342.00
15. 12" STEEL GIBSON CATCH BASIN WITH DOMED TOP AND 0.72" ORIFICE FLOW CONTROL PER DETAIL 13/C6.01.
   RIM=338.17
   IE=337.17



KEY MAP

SCALE: 1"=120'

PRELIMINARY
NOT FOR
CONSTRUCTION

CARLETON HART ARCHITECTURE P.C.
830 sw 10th avenue #200 portland oregon 97205
503.243.2252 | www.carletonhart.com

VEGA
CIVIL ENGINEERING LLC
503.662.1901 | WWW.VEGACIVIL.COM

PLAMBECK GARDENS
COMMUNITY PARTNERS FOR AFFORDABLE HOUSING
23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon 97062

LAND USE: ARCHITECTURAL REVIEW

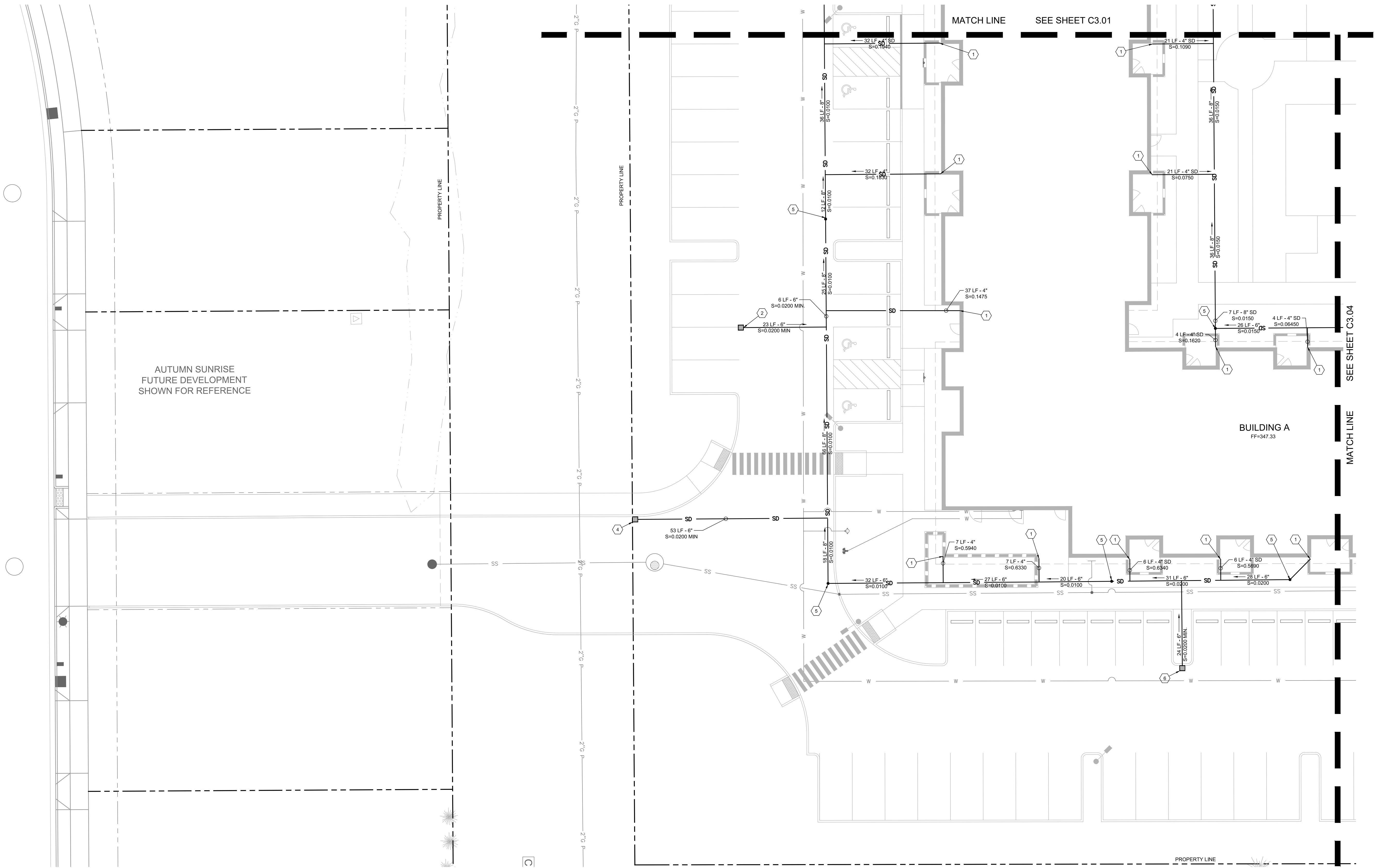
STORMWATER PLAN - SOUTHWEST

PROJECT NO.
#19031

03.04.2022

REVISIONS:

C3.01



STORMWATER PLAN - SOUTHEAST

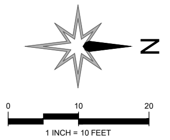
SCALE: 1"=10'

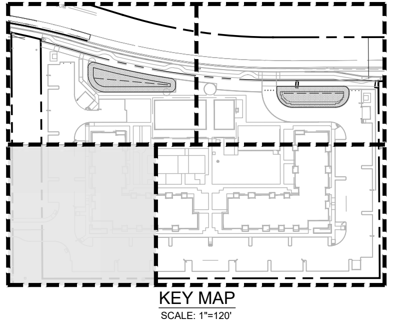
STORMWATER NOTES

1. ROOF DRAIN CONNECTION FROM BUILDING A.
   IE=343.33
2. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=344.86
   IE=342.86
3. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=345.58
   IE=343.58
4. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=346.30
   IE=341.30
5. STORMWATER CLEANOUT TO GRADE PER DETAIL 5/C6.01.
6. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=345.58
   IE=343.58

GENERAL NOTES

1. INSTALL "NO DUMPING / LEADS TO GROUNDWATER" MARKER AT ALL ONSITE CATCH BASINS PER DETAIL 11/C6.00.
2. FOR OTHER UTILITIES SEE SHEET C4.02.
3. COORDINATE ALL RETAINING WALL PENETRATIONS WITH STRUCTURAL PLANS.





KEY MAP

SCALE: 1"=120'

PRELIMINARY
NOT FOR
CONSTRUCTION

CARLETON HART ARCHITECTURE P.C.
830 sw 10th avenue #200 portland oregon 97205
503.243.2252 | www.carletonhart.com

VEGA
CIVIL ENGINEERING LLC
503.662.1901 | WWW.VEGACIVIL.COM

PLAMBECK GARDENS
COMMUNITY PARTNERS FOR AFFORDABLE HOUSING
23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon 97062

LAND USE: ARCHITECTURAL REVIEW

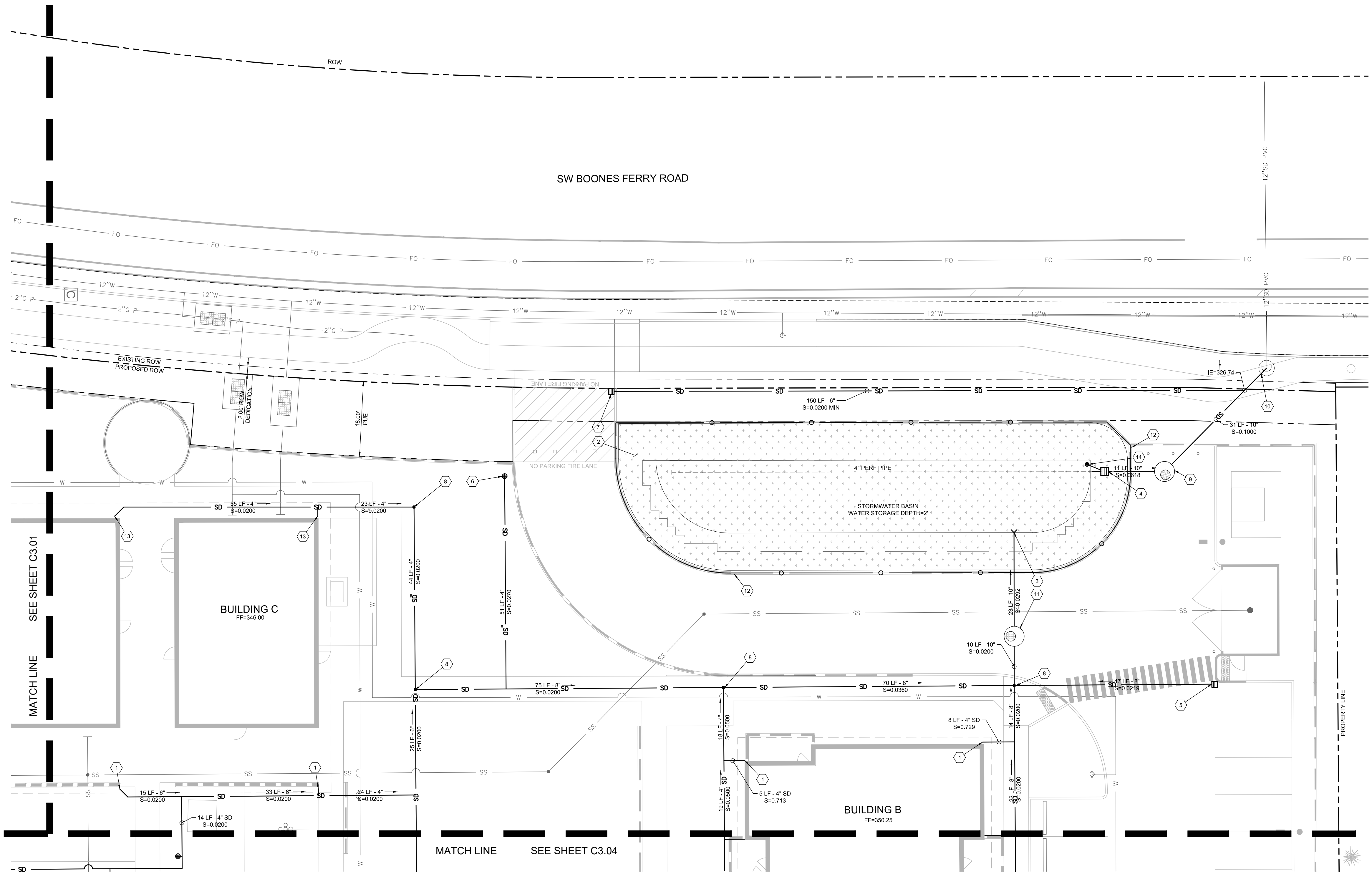
STORMWATER PLAN - SOUTHEAST

PROJECT NO.
#19031

03.04.2022

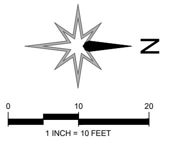
REVISIONS:

C3.02



STORMWATER PLAN - NORTHWEST

SCALE: 1"=10'

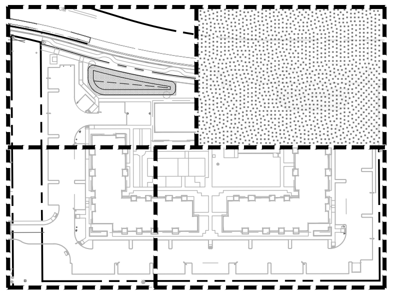


GENERAL NOTES

1. ALL WORK IN PUBLIC RIGHT-OF-WAY UNDER SEPARATE CITY OF TUALATIN PUBLIC WORKS PERMIT AND WASHINGTON COUNTY FACILITIES PERMIT. REFERENCE PUBLIC PLANS.
2. INSTALL "NO DUMPING / LEADS TO GROUNDWATER" MARKER AT ALL ONSITE CATCH BASINS PER DETAIL 11/C6.00.
3. FOR OTHER UTILITIES SEE SHEET C4.01.
4. COORDINATE ALL RETAINING WALL PENETRATIONS WITH STRUCTURAL PLANS.

STORMWATER NOTES

1. ROOF DRAIN CONNECTION FROM BUILDING B.
   IE=343.00
2. STORMWATER BASIN WITH 550 OLDCASTLE CUDO STORAGE CHAMBERS PER DETAIL 7/C6.01
   AREA MANAGED=66,479 SF
   BOTTOM AREA=2,200 SF
   BOTTOM ELEVATION=336.25
   WATER STORAGE DEPTH=2.0'
3. OUTFALL TO STORMWATER BASIN.
   IE=336.25
4. DITCH INLET PER CWS STANDARD DRAWING NO. 390
   FLOW INVERT=337.95
   IE,IN=329.83
   IE,OUT=329.83
5. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=342.46
   IE=340.46
6. 12" DOMED AREA DRAIN PER DETAIL 3/C6.01
   RIM=343.42
   IE=340.92
7. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=333.67
   IE=332.17
8. STORMWATER CLEANOUT TO GRADE PER DETAIL 5/C6.01.
9. FLOW CONTROL MANHOLE PER DETAIL 6/C6.01
   RIM=340.50
   10" OVERFLOW=337.20
   3.0" ORIFICE=336.88
   0.5" ORIFICE=329.00
   IE,IN=329.00
10. CONNECT TO EXISTING STORM FACILITY
   RIM=328.89
   IE(E)=323.05
   NEW 12" IE=326.04
11. WATER QUALITY MANHOLE PER CWS STANDARD DRAWING NO. 250 AND 260
   RIM=342.91
   IE=336.91
12. CURB SCUPPER PER DETAIL 10/C6.01.
13. ROOF DRAIN CONNECTION FROM BUILDING C.
   IE=342.50
14. 12" STEEL GIBSON CATCH BASIN WITH DOMED TOP AND 0.71" ORIFICE FLOW CONTROL PER DETAIL 13/C6.01.
   RIM=336.25
   IE=335.25



KEY MAP

SCALE: 1"=120'

PRELIMINARY
NOT FOR
CONSTRUCTION

CARLETON HART ARCHITECTURE P.C.
830 sw 10th avenue #200 portland oregon 97205
503.243.2252 | www.carletonhart.com

VEGA
CIVIL ENGINEERING LLC
503.662.1901 | WWW.VEGACIVIL.COM

PLAMBECK GARDENS
COMMUNITY PARTNERS FOR AFFORDABLE HOUSING
23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon 97062

LAND USE: ARCHITECTURAL REVIEW

STORMWATER PLAN - NORTHWEST

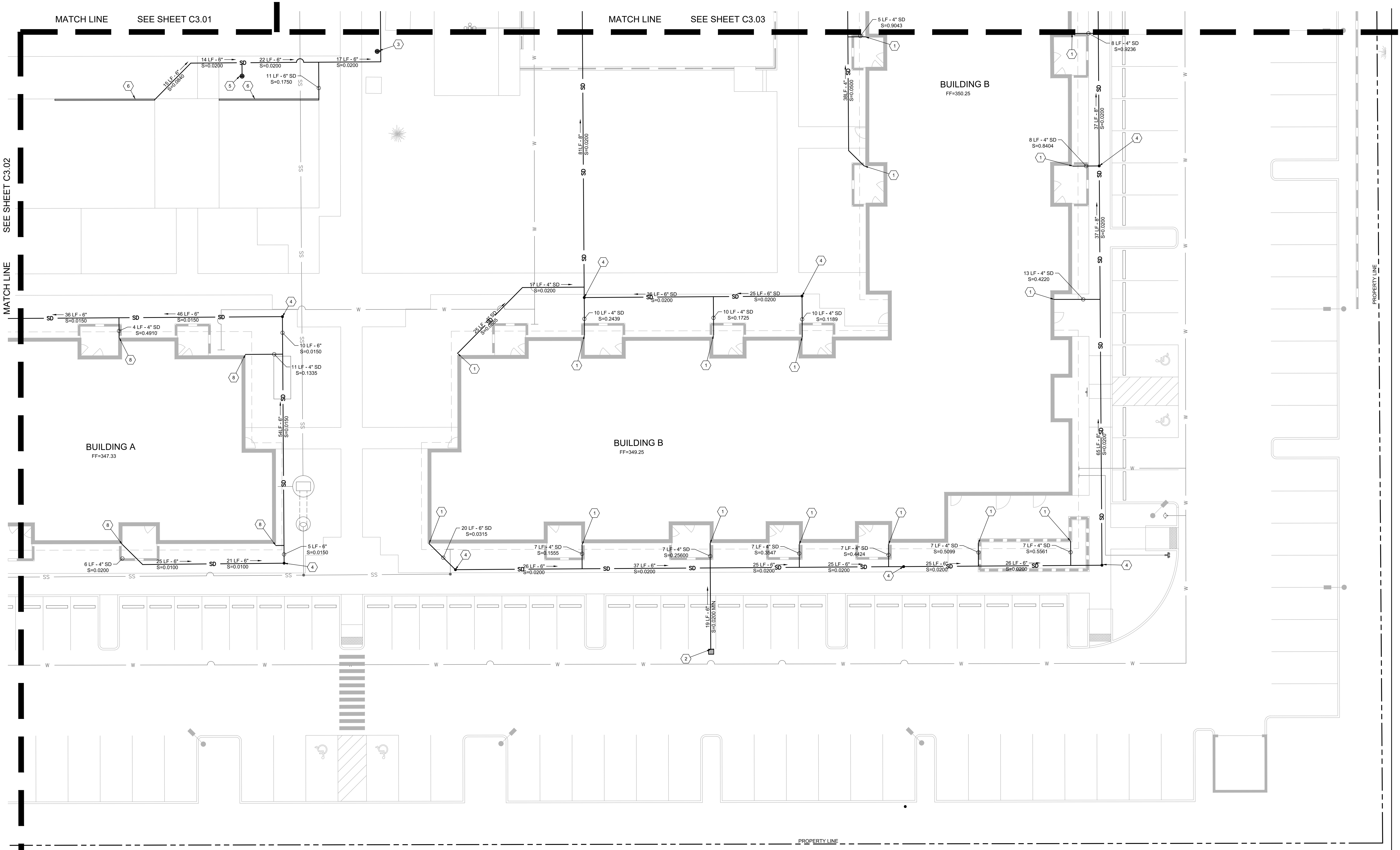
PROJECT NO.
#19031

03.04.2022

REVISIONS:

C3.03

PRELIMINARY
NOT FOR
CONSTRUCTION



STORMWATER PLAN - NORTHEAST

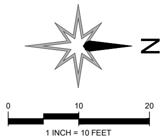
SCALE: 1"=10'

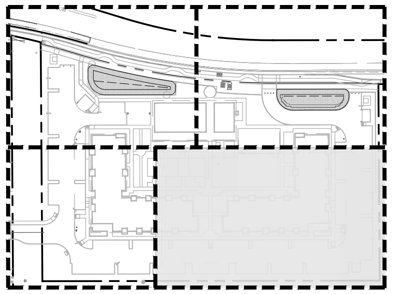
STORMWATER NOTES

1. ROOF DRAIN CONNECTION FROM BUILDING B.
   IE=344.75
2. 18" SQUARE PARKING LOT CATCH BASIN PER DETAIL 4/C6.01
   RIM=346.65
   IE=344.65
3. 12" DOMED LANDSCAPE AREA DRAIN PER DETAIL 3/C6.01
   RIM=345.85
   IE=343.85
4. STORMWATER CLEANOUT TO GRADE PER DETAIL 5/C6.01.
5. 12" DOMED LANDSCAPE AREA DRAIN PER DETAIL 3/C6.01
   RIM=345.33
   IE=343.33
6. TRENCH DRAIN. SEE ARCHITECTURAL PLANS
   RIM=345.65
   IE=344.15
7. TRENCH DRAIN, SEE ARCHITECTURAL PLANS
   RIM=345.75
   IE=344.25
8. ROOF DRAIN CONNECTION FROM BUILDING A.
   IE=345.83

GENERAL NOTES

1. INSTALL "NO DUMPING / LEADS TO GROUNDWATER" MARKER AT ALL ONSITE CATCH BASINS PER DETAIL 11/C6.00.
2. FOR OTHER UTILITIES SEE SHEET C4.02.
3. COORDINATE ALL RETAINING WALL PENETRATIONS WITH STRUCTURAL PLANS.





KEY MAP

SCALE: 1"=120'

CARLETON HART ARCHITECTURE P.C.
830 sw 10th avenue #200 portland oregon 97205
503.243.2252 | www.carletonhart.com

VEGA
CIVIL ENGINEERING LLC
503.662.1901 | WWW.VEGACIVIL.COM

PLAMBECK GARDENS
COMMUNITY PARTNERS FOR AFFORDABLE HOUSING
23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon 97062

LAND USE: ARCHITECTURAL REVIEW

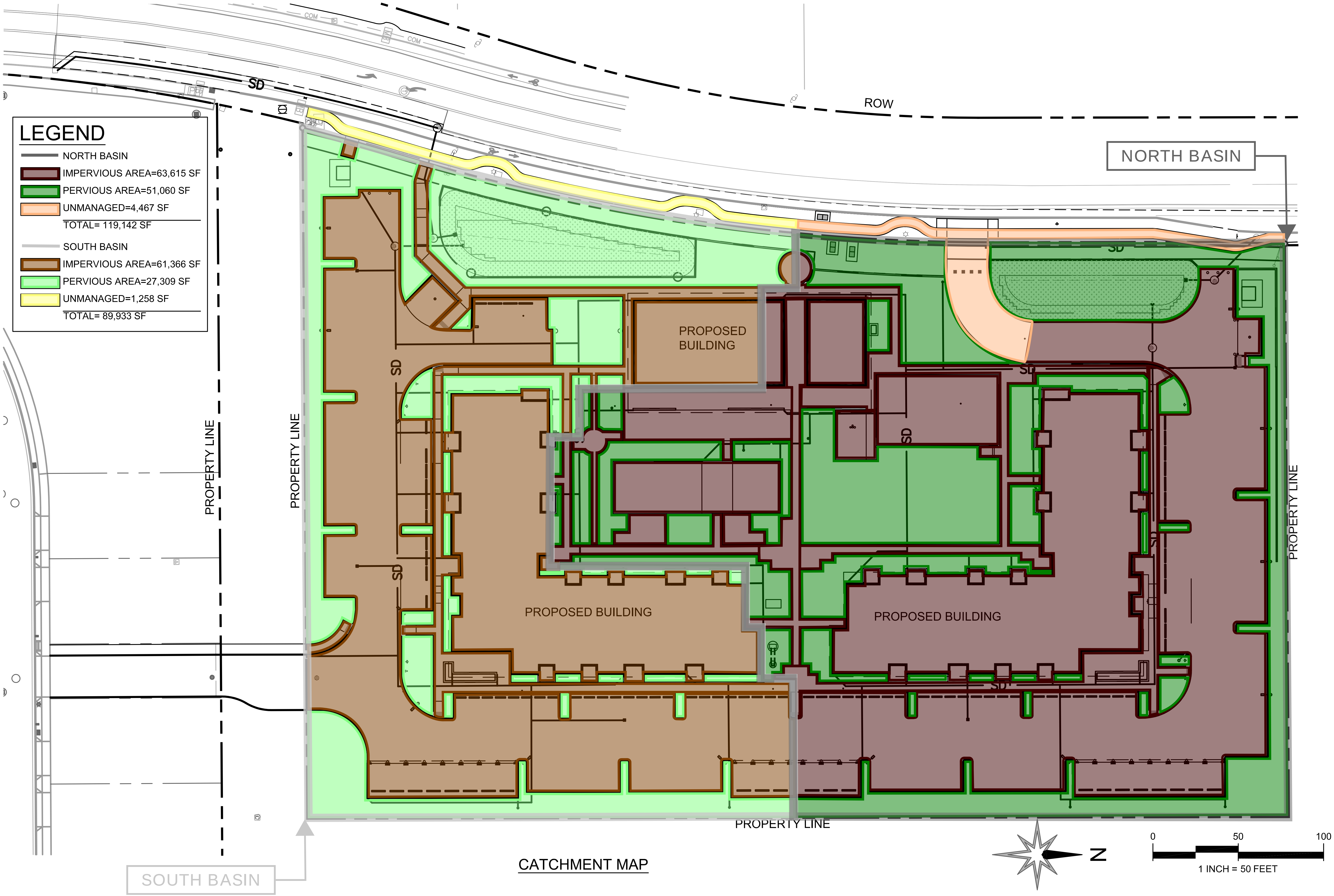
STORMWATER PLAN - NORTHEAST

PROJECT NO.
#19031

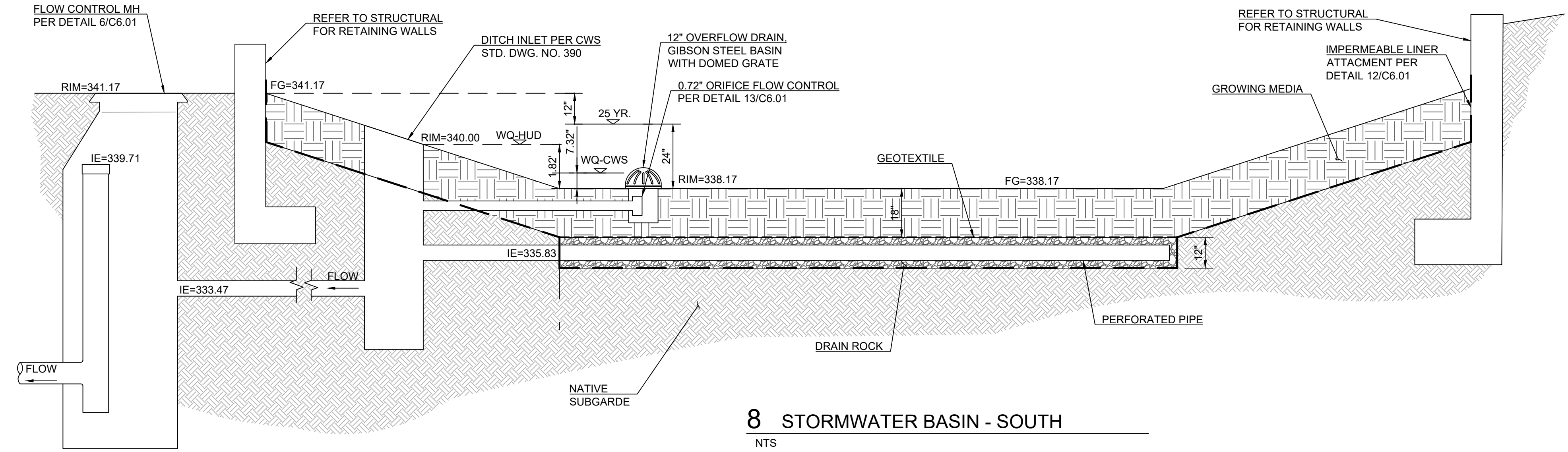
03.04.2022

REVISIONS:

C3.04

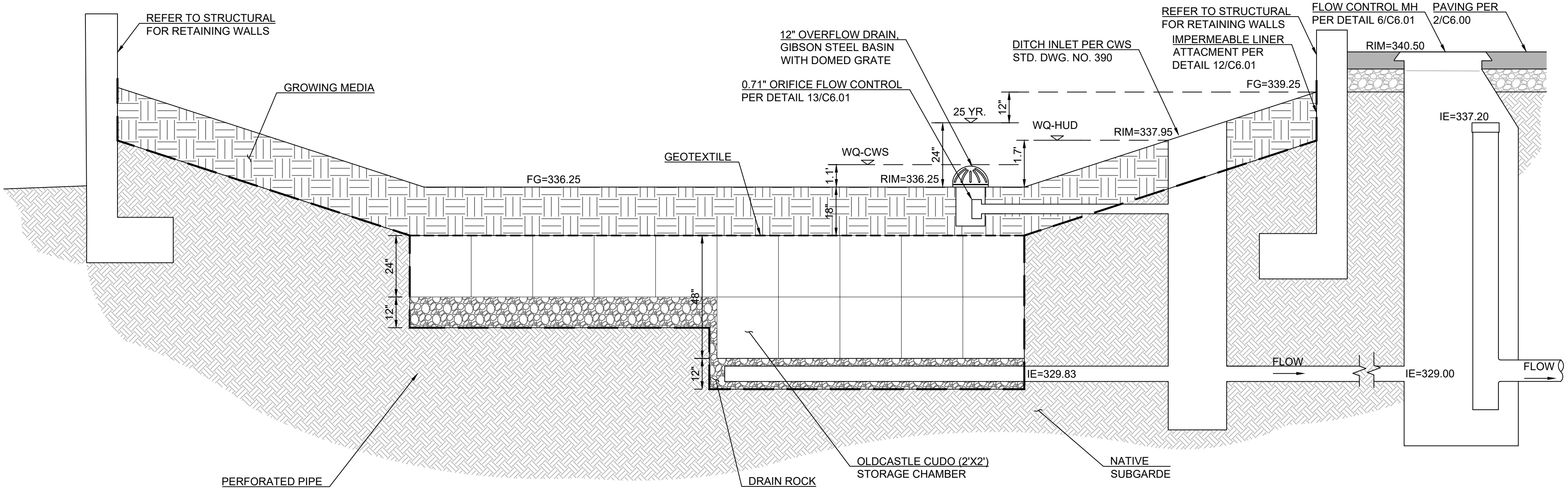


CATCHMENT MAP



8 STORMWATER BASIN - SOUTH

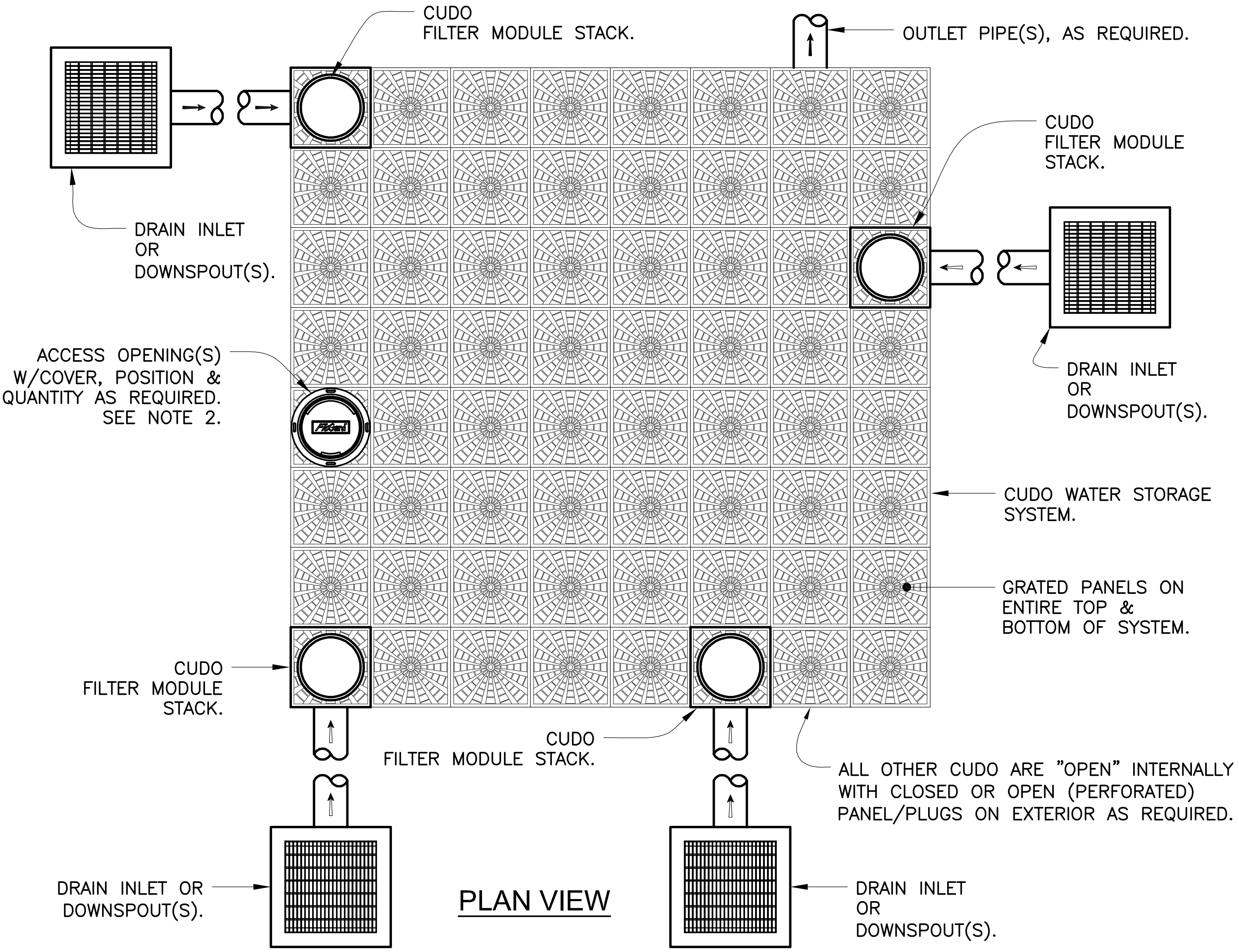
NTS



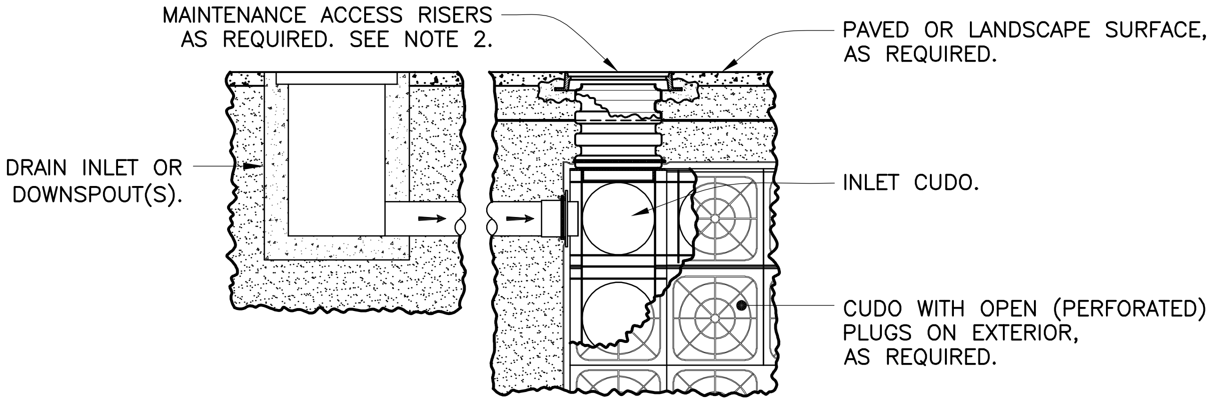
7 STORMWATER BASIN - NORTH

NTS

CUDO-0007



PLAN VIEW



SIDE SECTION VIEW

NOTES:

1. REFER TO CUDO INSTALLATION DETAILS.
2. SEE CUDO–0008 FOR TYPICAL MAINTENANCE ACCESS CONFIGURATION.

Detention/
Infiltration

CUDO®
Water Storage System
Typical System Layout
w/ Filter Module Stacks

Oldcastle®
Stormwater Solutions

7921 Southpark Plaza, Suite 200 | Littleton, CO | 80120 | Ph: 800.579.8819 | oldcastlestormwater.com

DRAWING NO.	REV	ECO	DATE	
CUDO-0007	C	ECO–0154 ZHD 2/6/18	JPR 5/2/08	SHEET 1 OF 1

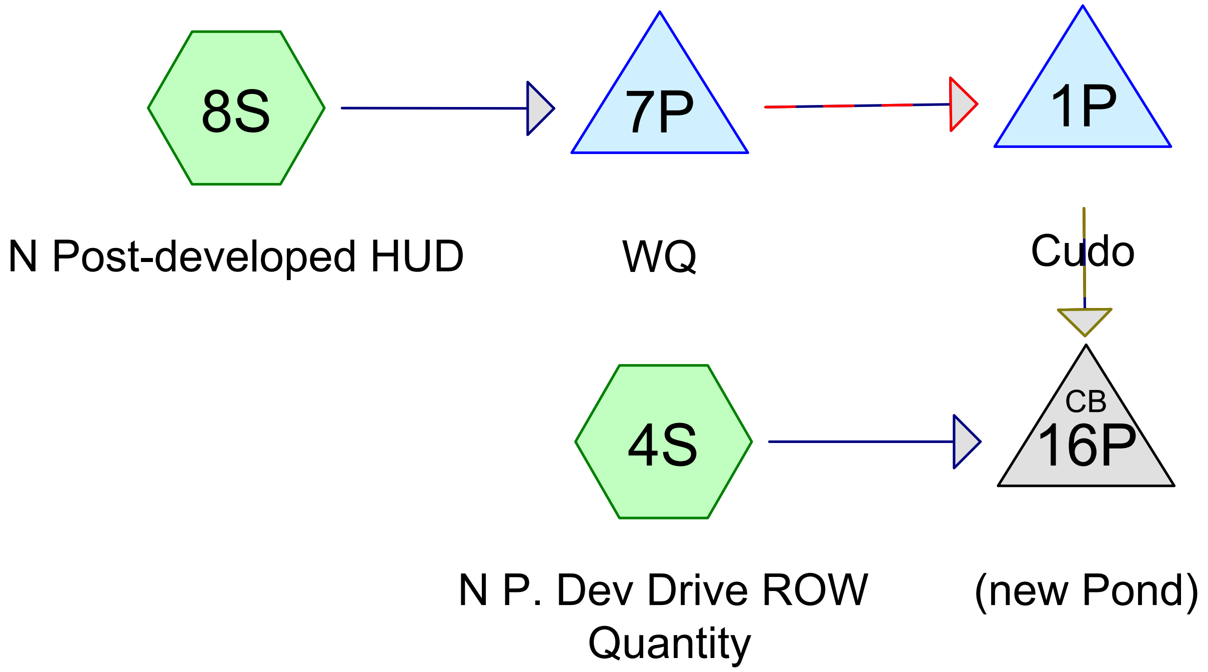
Appendix B: Stormwater Calculations

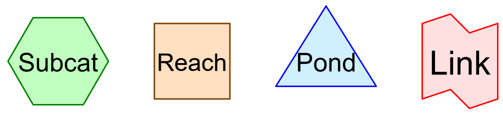
HydroCad Reports
Water Quality Calculations

HYDROCAD REPORT

TABLE OF CONTENTS

NORTH BASIN ROUTING DIAGRAM





Routing Diagram for Plambeck Gardens AW
Prepared by {enter your company name here}, Printed 2/25/2022
HydroCAD® 10.00-26 s/n 10966 © 2020 HydroCAD Software Solutions LLC

NORTH BASIN 2-YEAR STORM

NORTH PREDEVELOPED 2-YEAR STORM

Summary for Subcatchment 2S: Pre North

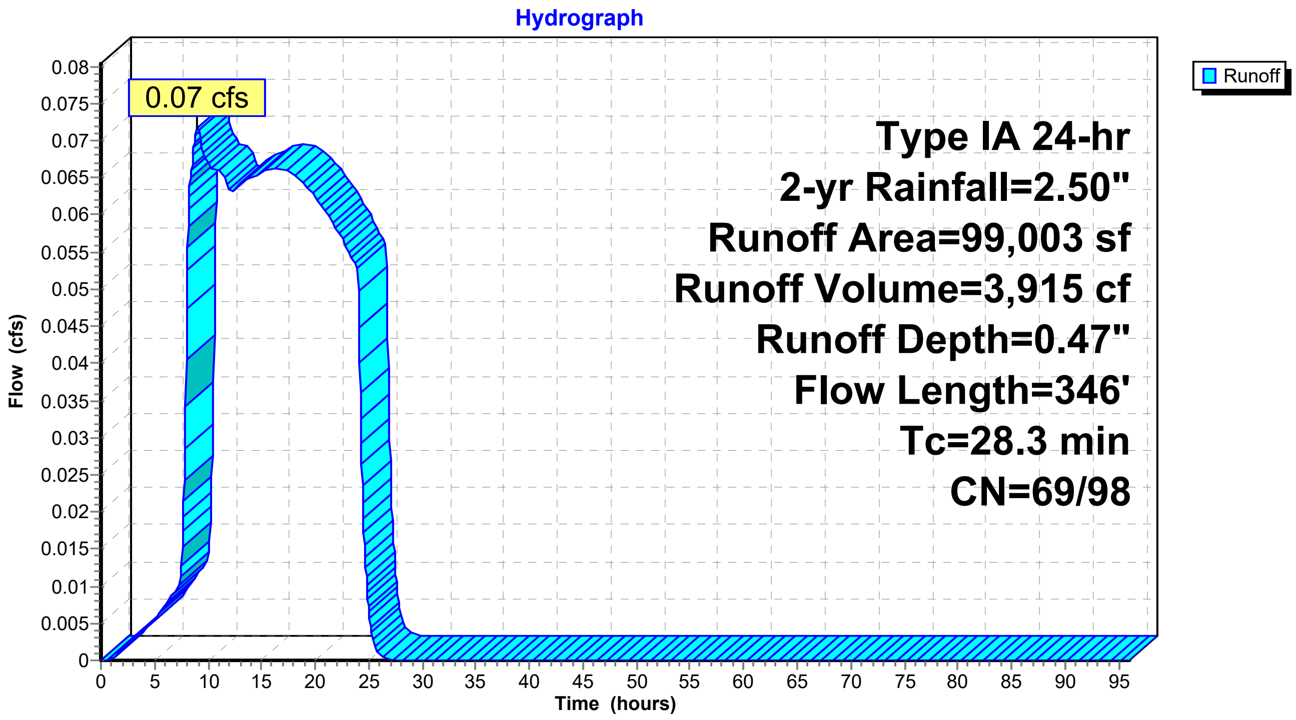
Runoff = 0.07 cfs @ 8.98 hrs, Volume= 3,915 cf, Depth= 0.47"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2-yr Rainfall=2.50"

Area (sf)	CN	Description
860	85	Gravel roads, HSG B
450	98	Paved parking, HSG B
2,422	98	Roofs, HSG B
92,895	69	Pasture/grassland/range, Fair, HSG B
2,376	69	Pasture/grassland/range, Fair, HSG B
99,003	70	Weighted Average
96,131	69	97.10% Pervious Area
2,872	98	2.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.1	300	0.0450	0.18		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.2	46	0.0650	3.82		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
28.3	346	Total			

Subcatchment 2S: Pre North



NORTH POST-DEVELOPED BASIN RUNOFF - 2-YEAR STORM

Summary for Subcatchment 8S: N Post-developed HUD

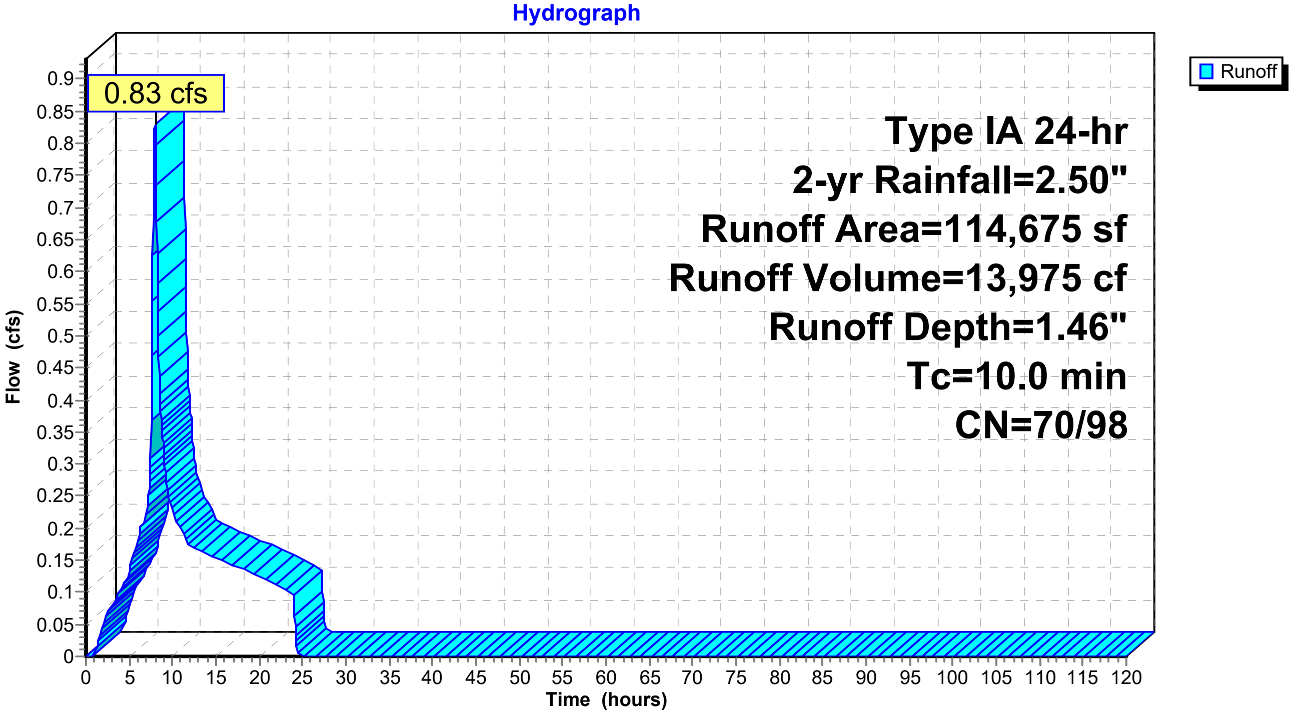
Runoff = 0.83 cfs @ 7.99 hrs, Volume= 13,975 cf, Depth= 1.46"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2-yr Rainfall=2.50"

	Area (sf)	CN	Description
*	63,615	98	
	3,514	85	Gravel roads, HSG B
	47,546	69	50-75% Grass cover, Fair, HSG B
	114,675	86	Weighted Average
	51,060	70	44.53% Pervious Area
	63,615	98	55.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 8S: N Post-developed HUD



Summary for Pond 1P: Cudo

[81] Warning: Exceeded Pond 7P by 4.51' @ 114.75 hrs
[81] Warning: Exceeded Pond 7P by 4.51' @ 114.75 hrs

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth > 1.41" for 2-yr event
Inflow = 0.33 cfs @ 8.93 hrs, Volume= 13,439 cf
Outflow = 0.01 cfs @ 48.27 hrs, Volume= 5,778 cf, Atten= 95%, Lag= 2,360.2 min
Primary = 0.01 cfs @ 48.27 hrs, Volume= 5,778 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 105.11' @ 48.27 hrs Surf.Area= 2,854 sf Storage= 8,686 cf

Plug-Flow detention time= 3,200.9 min calculated for 5,776 cf (43% of inflow)
Center-of-Mass det. time= 2,086.6 min (3,906.2 - 1,819.6)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	13,467 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,220	0.0	0	0	2,220
101.00	2,220	30.0	666	666	2,408
103.00	2,220	95.0	4,218	4,884	2,785
103.01	1,722	20.0	4	4,888	3,283
103.51	1,722	20.0	172	5,060	3,366
106.50	4,067	100.0	8,407	13,467	5,794

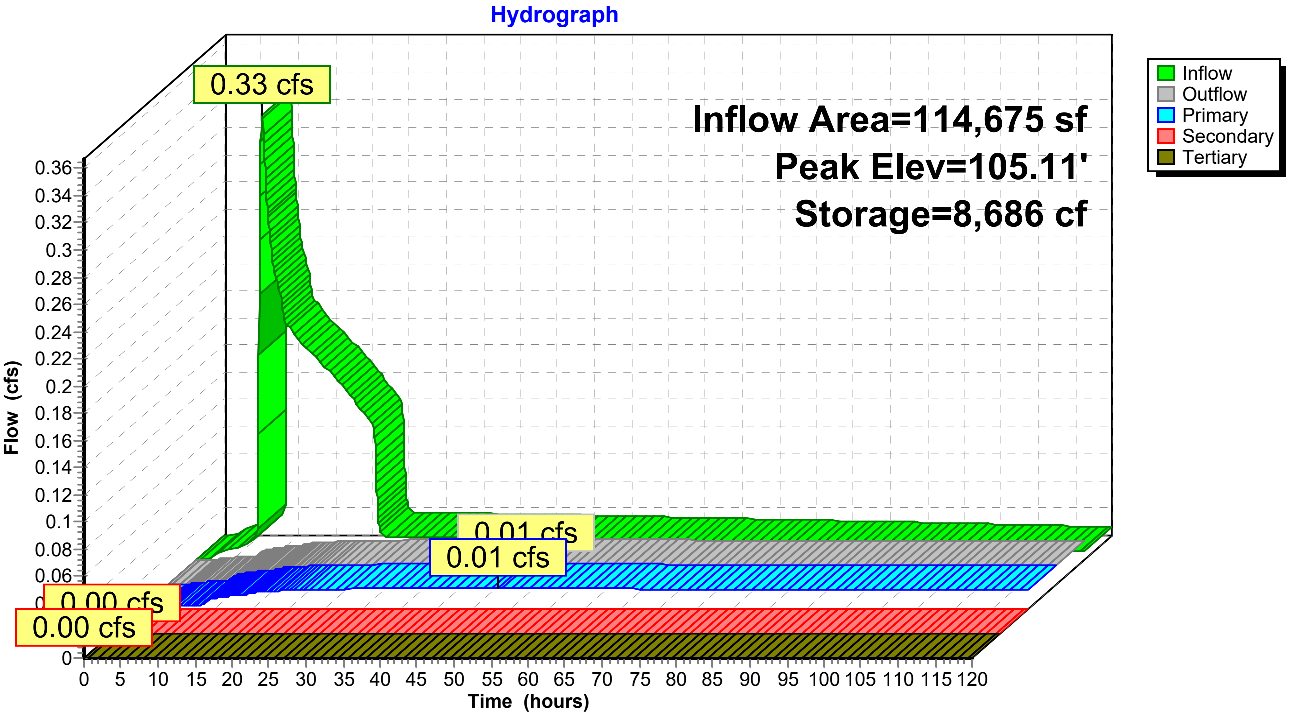
Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.50" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	105.13'	**3.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	105.45'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.01 cfs @ 48.27 hrs HW=105.11' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.01 cfs @ 10.89 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=100.00' (Free Discharge)
↑—**2=Orifice/Grate** (Controls 0.00 cfs)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=100.00' (Free Discharge)
↑—**3=Orifice/Grate** (Controls 0.00 cfs)

Pond 1P: Cudo


Hydrograph
0.33 cfs
Inflow Area=114,675 sf
Peak Elev=105.11'
Storage=8,686 cf
0.01 cfs
0.01 cfs
0.00 cfs
0.00 cfs
Inflow
Outflow
Primary
Secondary
Tertiary
Flow (cfs)
0.36
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0
Time (hours)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

Summary for Pond 7P: WQ

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth = 1.46" for 2-yr event
Inflow = 0.83 cfs @ 7.99 hrs, Volume= 13,975 cf
Outflow = 0.33 cfs @ 8.93 hrs, Volume= 13,439 cf, Atten= 61%, Lag= 56.7 min
Primary = 0.02 cfs @ 8.93 hrs, Volume= 5,363 cf
Secondary = 0.31 cfs @ 8.93 hrs, Volume= 8,076 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 101.80' @ 8.93 hrs Surf.Area= 3,279 sf Storage= 4,949 cf

Plug-Flow detention time= 1,129.4 min calculated for 13,433 cf (96% of inflow)
Center-of-Mass det. time= 1,103.8 min (1,819.6 - 715.8)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	9,360 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

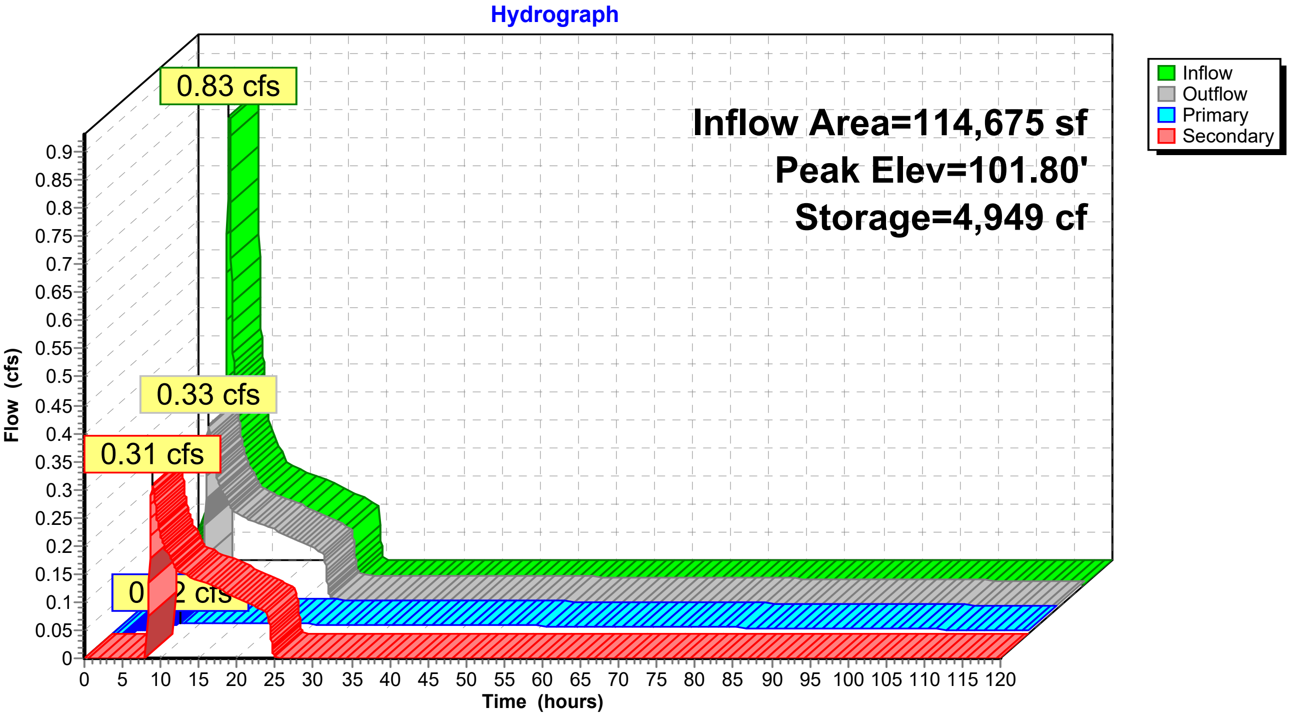
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,261	0.0	0	0	2,261
103.00	4,067	100.0	9,360	9,360	4,187

Device	Routing	Invert	Outlet Devices
#1	Primary	100.01'	**0.71" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.70'	**12.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.02 cfs @ 8.93 hrs HW=101.80' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 6.44 fps)

Secondary OutFlow Max=0.31 cfs @ 8.93 hrs HW=101.80' (Free Discharge)
↑—**2=Orifice/Grate** (Weir Controls 0.31 cfs @ 1.02 fps)

Pond 7P: WQ


Hydrograph
Inflow Area=114,675 sf
Peak Elev=101.80'
Storage=4,949 cf
0.83 cfs
0.33 cfs
0.31 cfs
0 2 cfs
🟩 Inflow
⬜ Outflow
🟦 Primary
🟥 Secondary
Flow (cfs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
Time (hours)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120

NORTH UNMANAGED DRIVEWAY RUNOFF - 2-YEAR STORM

Summary for Subcatchment 4S: N P. Dev Drive ROW Quantity

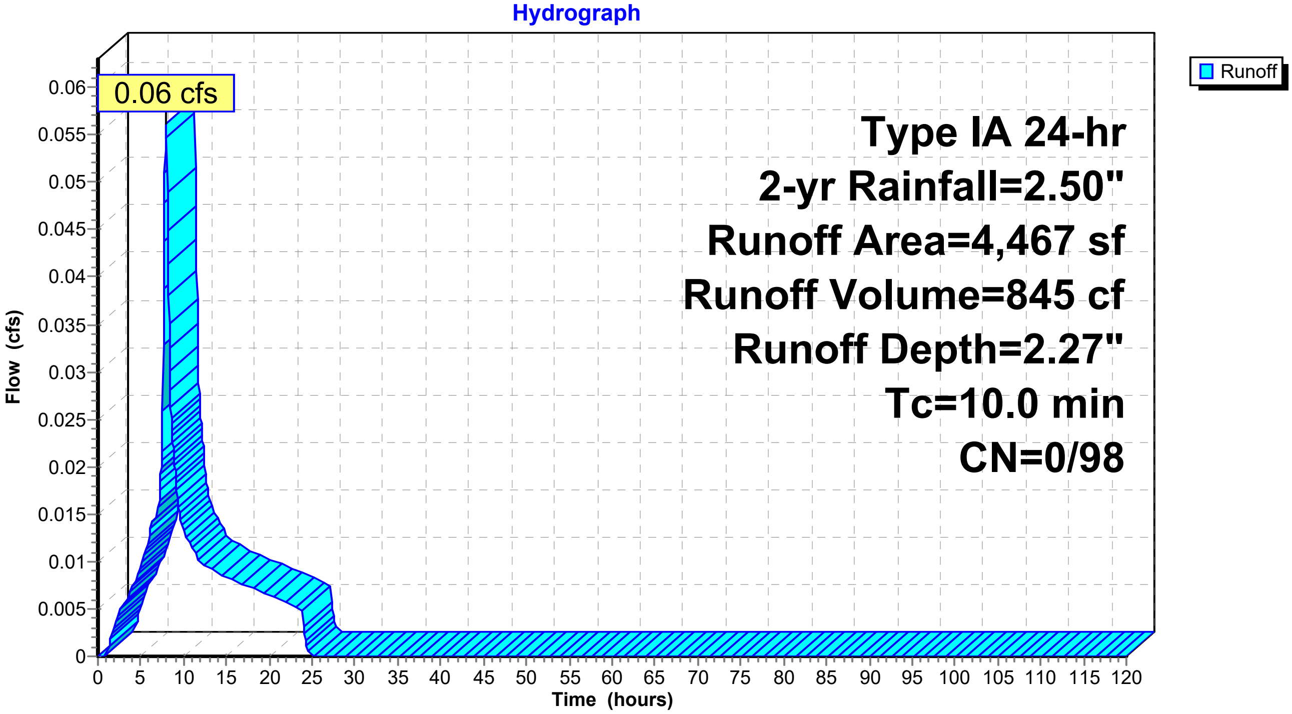
Runoff = 0.06 cfs @ 7.98 hrs, Volume= 845 cf, Depth= 2.27"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2-yr Rainfall=2.50"

	Area (sf)	CN	Description
*	4,467	98	New driveway
	4,467	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 4S: N P. Dev Drive ROW Quantity



NORTH TOTAL DISCHARGE FROM SITE - 2-YEAR STORM

Summary for Pond 16P: (new Pond)

[57] Hint: Peaked at 93.10' (Flood elevation advised)

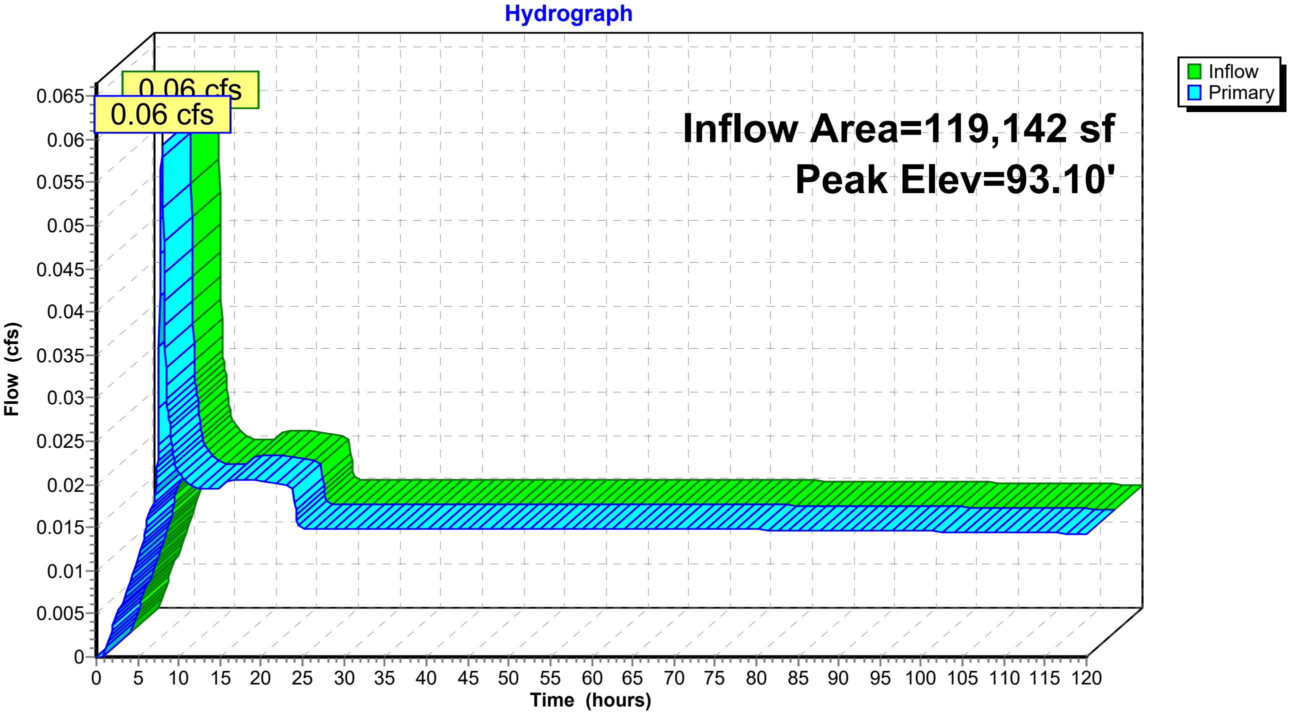
Inflow Area = 119,142 sf, 57.14% Impervious, Inflow Depth > 0.67" for 2-yr event
Inflow = 0.06 cfs @ 7.98 hrs, Volume= 6,623 cf
Outflow = 0.06 cfs @ 7.98 hrs, Volume= 6,623 cf, Atten= 0%, Lag= 0.0 min
Primary = 0.06 cfs @ 7.98 hrs, Volume= 6,623 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.10' @ 7.98 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**20.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.06 cfs @ 7.98 hrs HW=93.10' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.06 cfs @ 1.08 fps)

Pond 16P: (new Pond)



NORTH BASIN 5-YEAR STORM

Summary for Subcatchment 2S: Pre North

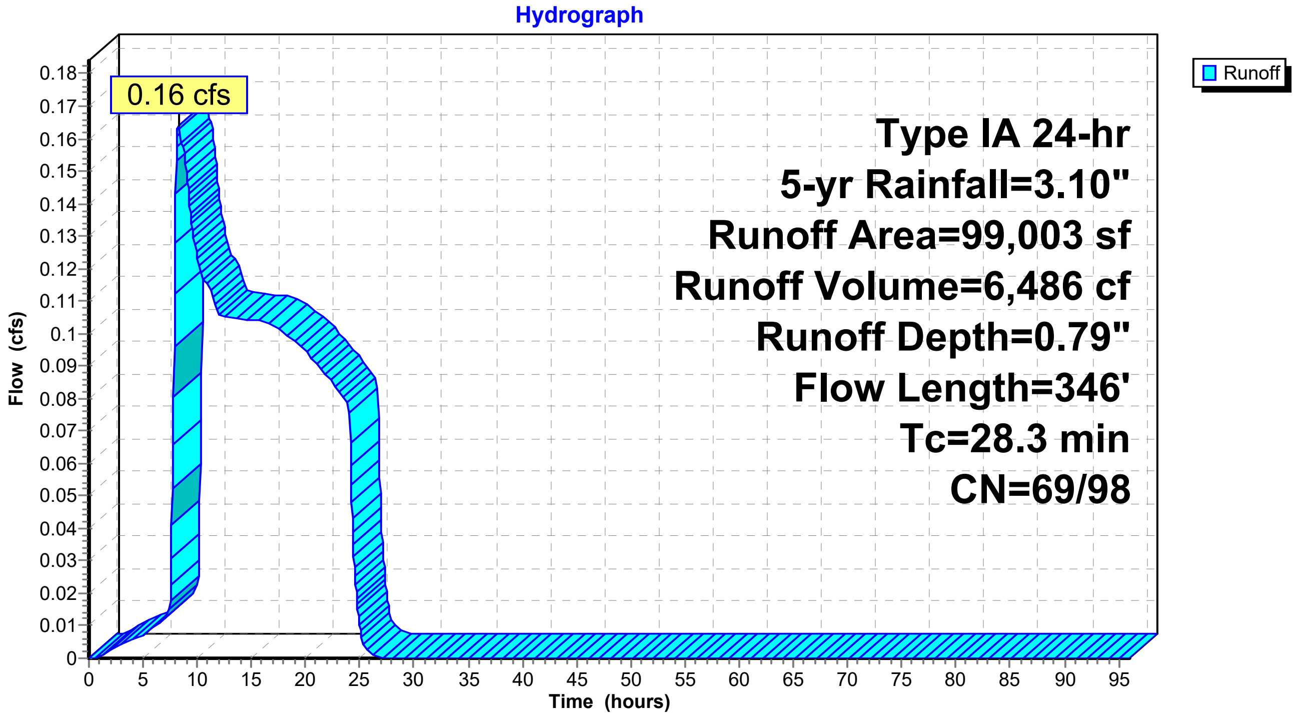
Runoff = 0.16 cfs @ 8.28 hrs, Volume= 6,486 cf, Depth= 0.79"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 5-yr Rainfall=3.10"

Area (sf)	CN	Description
860	85	Gravel roads, HSG B
450	98	Paved parking, HSG B
2,422	98	Roofs, HSG B
92,895	69	Pasture/grassland/range, Fair, HSG B
2,376	69	Pasture/grassland/range, Fair, HSG B
99,003	70	Weighted Average
96,131	69	97.10% Pervious Area
2,872	98	2.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.1	300	0.0450	0.18		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.2	46	0.0650	3.82		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
28.3	346	Total			

Subcatchment 2S: Pre North



Summary for Subcatchment 8S: N Post-developed HUD

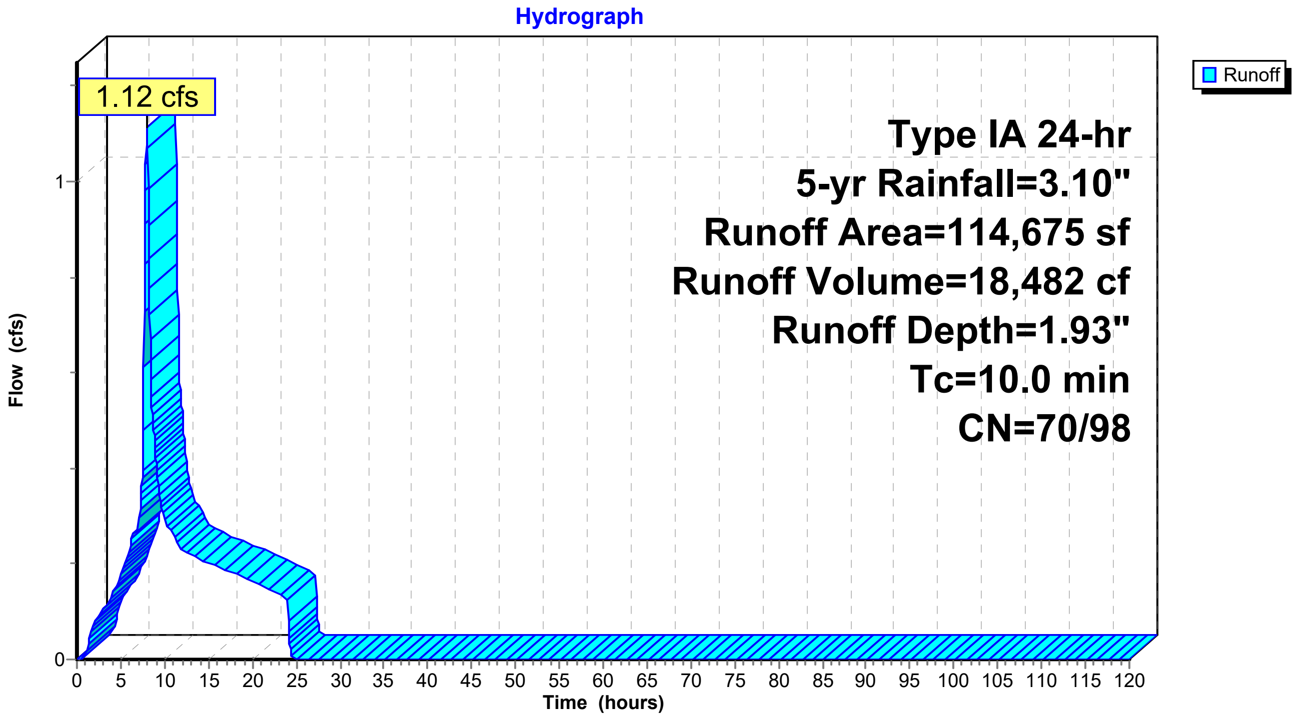
Runoff = 1.12 cfs @ 7.99 hrs, Volume= 18,482 cf, Depth= 1.93"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 5-yr Rainfall=3.10"

	Area (sf)	CN	Description
*	63,615	98	
	3,514	85	Gravel roads, HSG B
	47,546	69	50-75% Grass cover, Fair, HSG B
	114,675	86	Weighted Average
	51,060	70	44.53% Pervious Area
	63,615	98	55.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 8S: N Post-developed HUD



Summary for Pond 1P: Cudo

[81] Warning: Exceeded Pond 7P by 4.53' @ 114.70 hrs
[81] Warning: Exceeded Pond 7P by 4.53' @ 114.70 hrs

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth > 1.88" for 5-yr event
Inflow = 0.80 cfs @ 8.24 hrs, Volume= 17,944 cf
Outflow = 0.15 cfs @ 21.94 hrs, Volume= 10,232 cf, Atten= 82%, Lag= 822.0 min
Primary = 0.02 cfs @ 21.94 hrs, Volume= 5,922 cf
Secondary = 0.13 cfs @ 21.94 hrs, Volume= 4,310 cf
Tertiary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 105.45' @ 21.94 hrs Surf.Area= 3,127 sf Storage= 9,686 cf

Plug-Flow detention time= 2,072.4 min calculated for 10,228 cf (57% of inflow)
Center-of-Mass det. time= 1,227.7 min (2,781.1 - 1,553.4)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	13,467 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,220	0.0	0	0	2,220
101.00	2,220	30.0	666	666	2,408
103.00	2,220	95.0	4,218	4,884	2,785
103.01	1,722	20.0	4	4,888	3,283
103.51	1,722	20.0	172	5,060	3,366
106.50	4,067	100.0	8,407	13,467	5,794

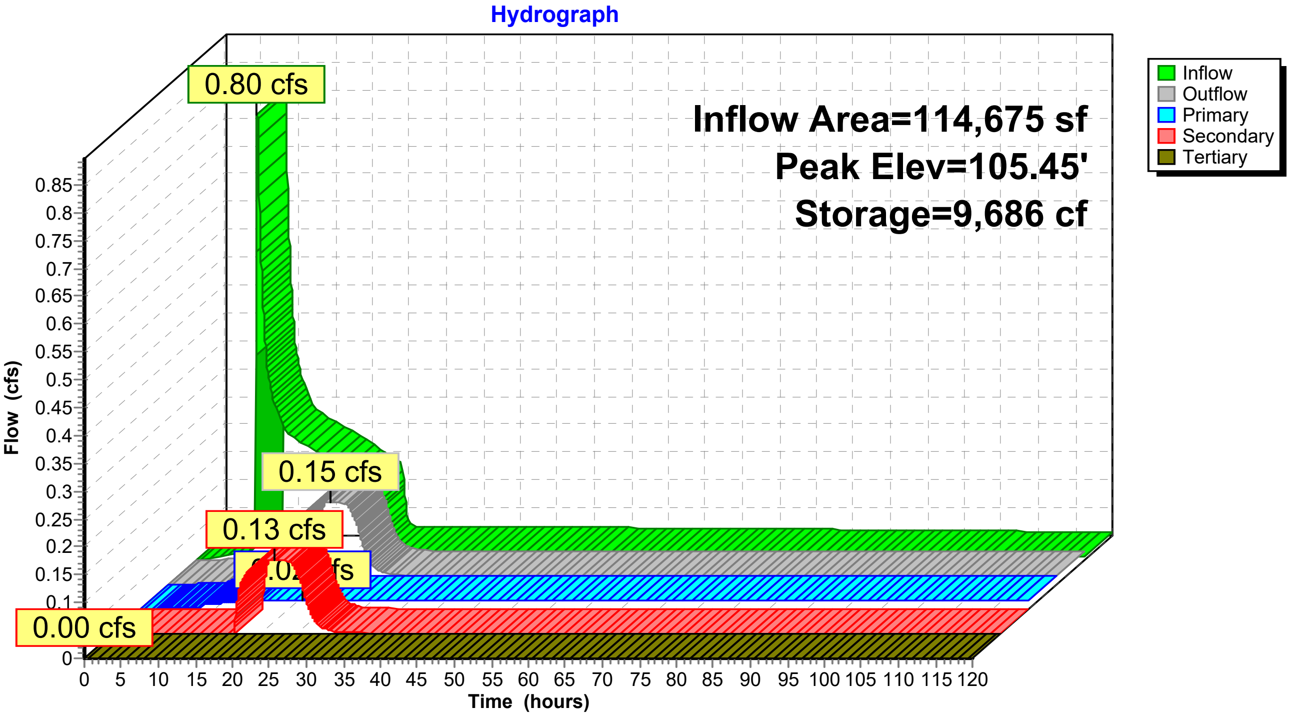
Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.50" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	105.13'	**3.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	105.45'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.02 cfs @ 21.94 hrs HW=105.45' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 11.24 fps)

Secondary OutFlow Max=0.13 cfs @ 21.94 hrs HW=105.45' (Free Discharge)
└─**2=Orifice/Grate** (Orifice Controls 0.13 cfs @ 2.71 fps)

Tertiary OutFlow Max=0.00 cfs @ 0.00 hrs HW=100.00' (Free Discharge)
└─**3=Orifice/Grate** (Controls 0.00 cfs)

Pond 1P: Cudo


Hydrograph
0.80 cfs
Inflow Area=114,675 sf
Peak Elev=105.45'
Storage=9,686 cf
0.15 cfs
0.13 cfs
0.02 cfs
0.00 cfs
🟩 Inflow
⬜ Outflow
🟦 Primary
🟥 Secondary
🟫 Tertiary
Flow (cfs)
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
Time (hours)

Summary for Pond 7P: WQ

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth = 1.93" for 5-yr event
Inflow = 1.12 cfs @ 7.99 hrs, Volume= 18,482 cf
Outflow = 0.80 cfs @ 8.24 hrs, Volume= 17,944 cf, Atten= 28%, Lag= 15.0 min
Primary = 0.02 cfs @ 8.24 hrs, Volume= 5,406 cf
Secondary = 0.78 cfs @ 8.24 hrs, Volume= 12,538 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 101.88' @ 8.24 hrs Surf.Area= 3,331 sf Storage= 5,222 cf

Plug-Flow detention time= 858.9 min calculated for 17,936 cf (97% of inflow)
Center-of-Mass det. time= 839.9 min (1,553.4 - 713.5)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	9,360 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

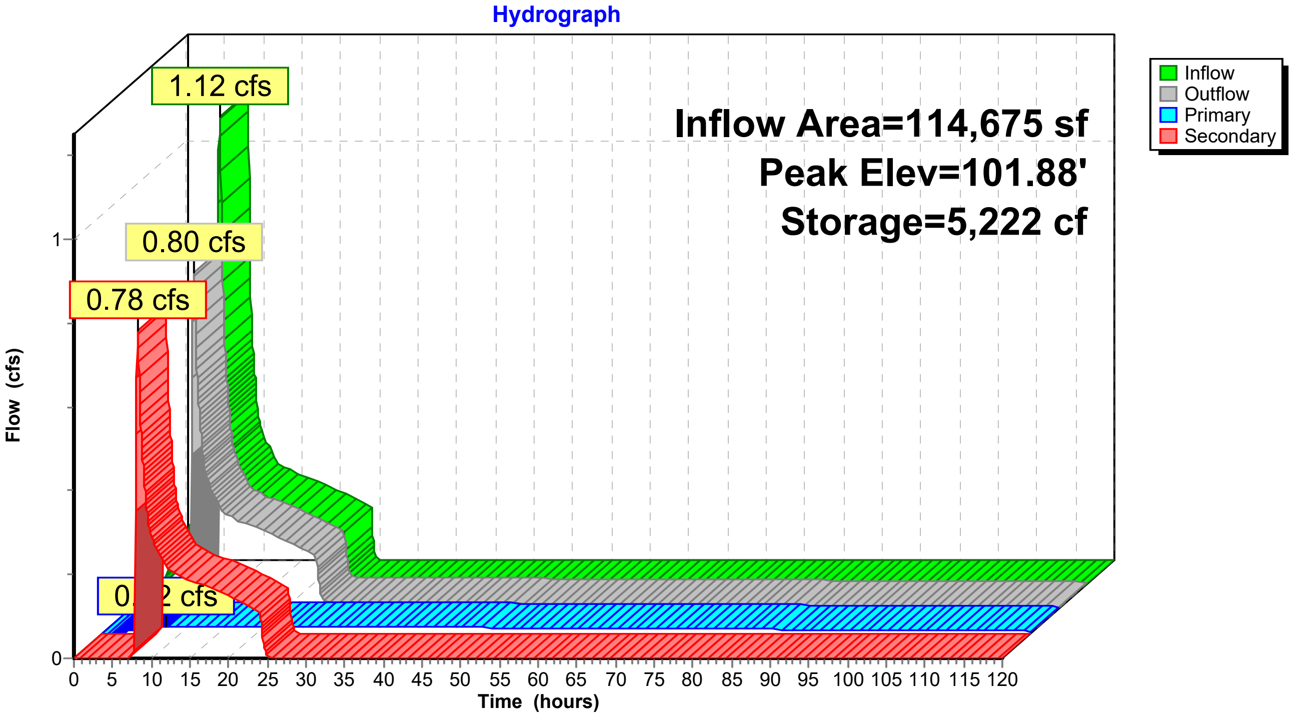
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,261	0.0	0	0	2,261
103.00	4,067	100.0	9,360	9,360	4,187

Device	Routing	Invert	Outlet Devices
#1	Primary	100.01'	**0.71" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.70'	**12.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.02 cfs @ 8.24 hrs HW=101.88' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 6.58 fps)

Secondary OutFlow Max=0.78 cfs @ 8.24 hrs HW=101.88' (Free Discharge)
└─**2=Orifice/Grate** (Weir Controls 0.78 cfs @ 1.38 fps)

Pond 7P: WQ


Hydrograph
1.12 cfs
0.80 cfs
0.78 cfs
0. 2 cfs
Inflow Area=114,675 sf
Peak Elev=101.88'
Storage=5,222 cf
🟩 Inflow
⬜ Outflow
🟦 Primary
🟥 Secondary
Flow (cfs)
1
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
Time (hours)

NORTH UNMANAGED DRIVEWAY RUNOFF - 5-YEAR STORM

Summary for Subcatchment 4S: N P. Dev Drive ROW Quantity

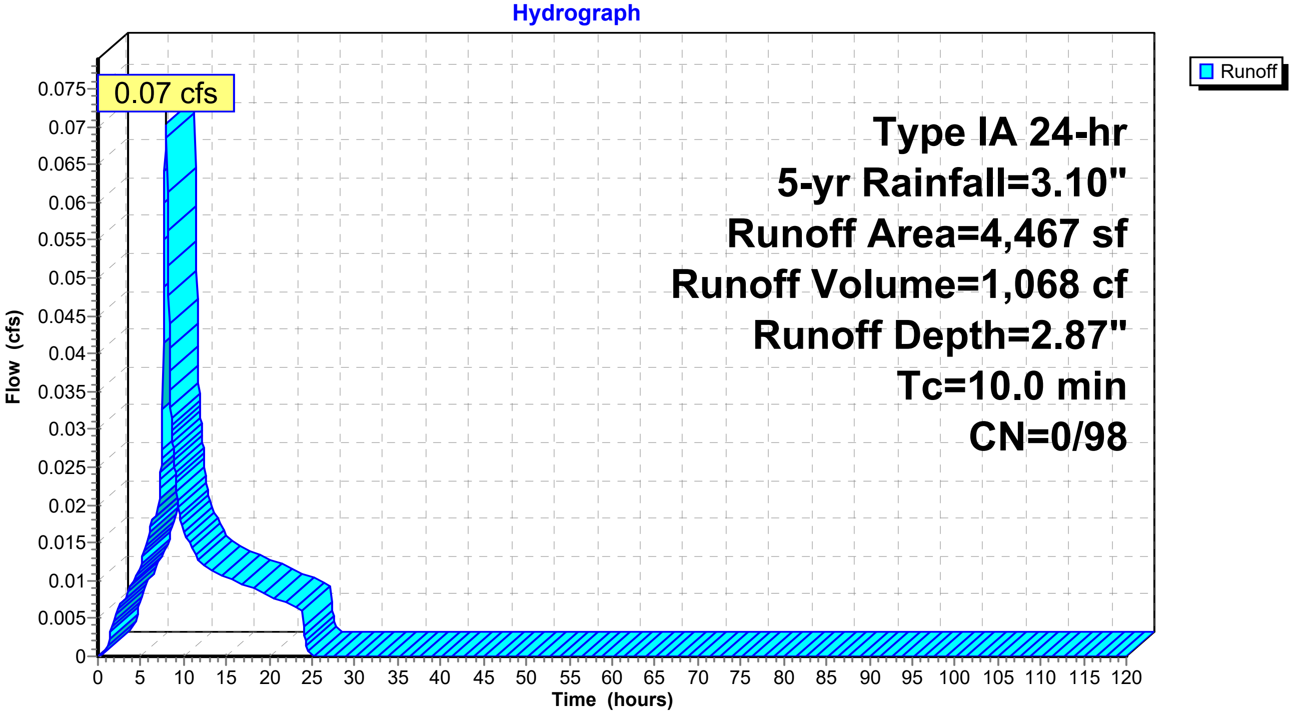
Runoff = 0.07 cfs @ 7.98 hrs, Volume= 1,068 cf, Depth= 2.87"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 5-yr Rainfall=3.10"

	Area (sf)	CN	Description
*	4,467	98	New driveway
	4,467	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 4S: N P. Dev Drive ROW Quantity

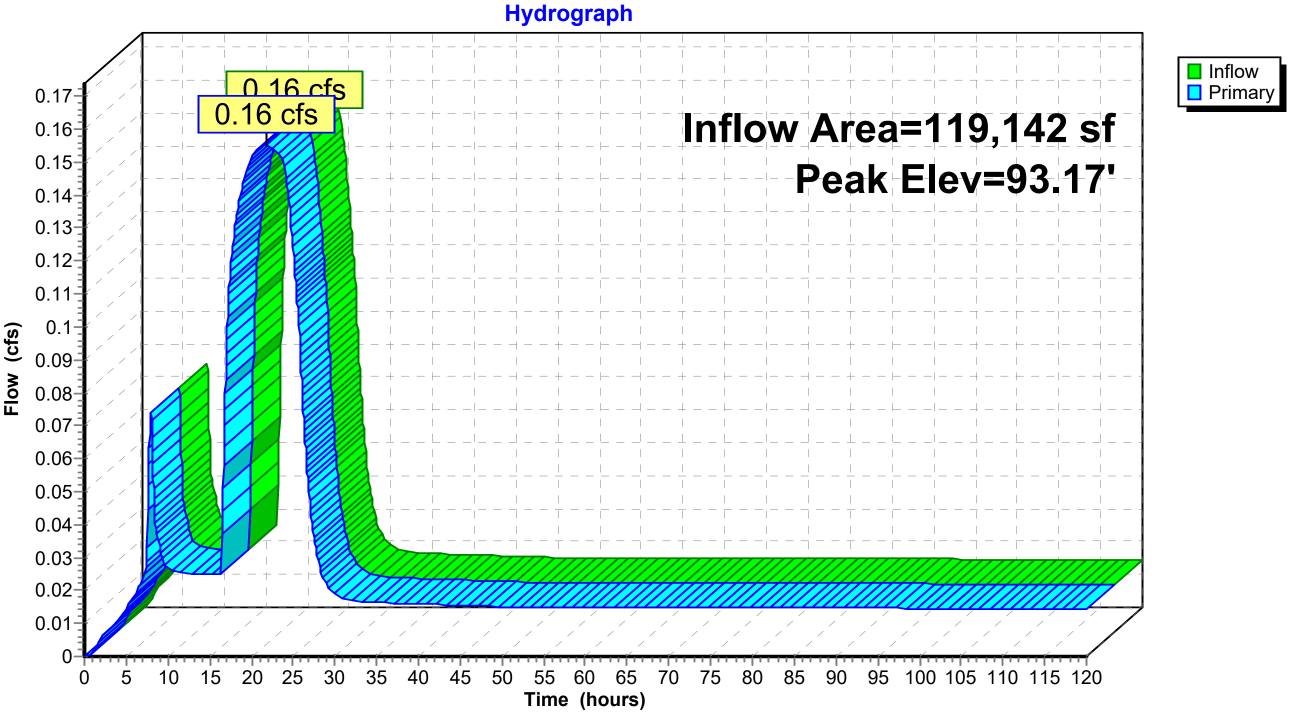


NORTH TOTAL DISCHARGE FROM SITE - 5-YEAR STORM

Summary for Pond 16P: (new Pond)

```
[57] Hint: Peaked at 93.17' (Flood elevation advised)

Inflow Area =       119,142 sf,  57.14% Impervious,  Inflow Depth >   1.14"   for  5-yr event
Inflow      =      0.16 cfs @  21.73 hrs,  Volume=          11,300 cf
Outflow     =      0.16 cfs @  21.73 hrs,  Volume=          11,300 cf,  Atten= 0%,  Lag= 0.0 min
Primary     =      0.16 cfs @  21.73 hrs,  Volume=          11,300 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.17' @ 21.73 hrs

Device   Routing            Invert   Outlet Devices
   #1    Primary            93.00'   20.00" Vert. Orifice/Grate   C= 0.600

Primary OutFlow  Max=0.16 cfs @ 21.73 hrs  HW=93.17'   (Free Discharge)
 └─1=Orifice/Grate  (Orifice Controls 0.16 cfs @ 1.38 fps)
```

Pond 16P: (new Pond)



NORTH BASIN 10-YEAR STORM

Summary for Subcatchment 2S: Pre North

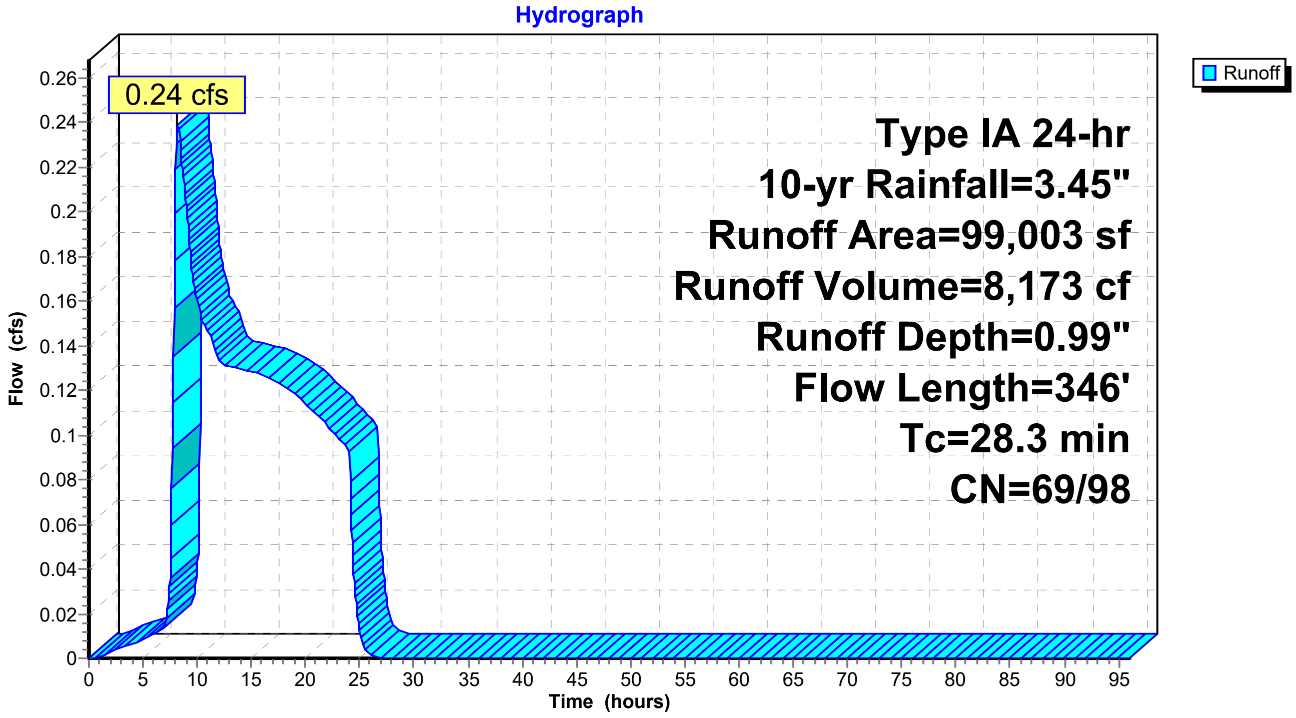
Runoff = 0.24 cfs @ 8.21 hrs, Volume= 8,173 cf, Depth= 0.99"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10-yr Rainfall=3.45"

Area (sf)	CN	Description
860	85	Gravel roads, HSG B
450	98	Paved parking, HSG B
2,422	98	Roofs, HSG B
92,895	69	Pasture/grassland/range, Fair, HSG B
2,376	69	Pasture/grassland/range, Fair, HSG B
99,003	70	Weighted Average
96,131	69	97.10% Pervious Area
2,872	98	2.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.1	300	0.0450	0.18		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.2	46	0.0650	3.82		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
28.3	346	Total			

Subcatchment 2S: Pre North



NORTH POST-DEVELOPED BASIN RUNOFF - 10-YEAR STORM

Summary for Subcatchment 8S: N Post-developed HUD

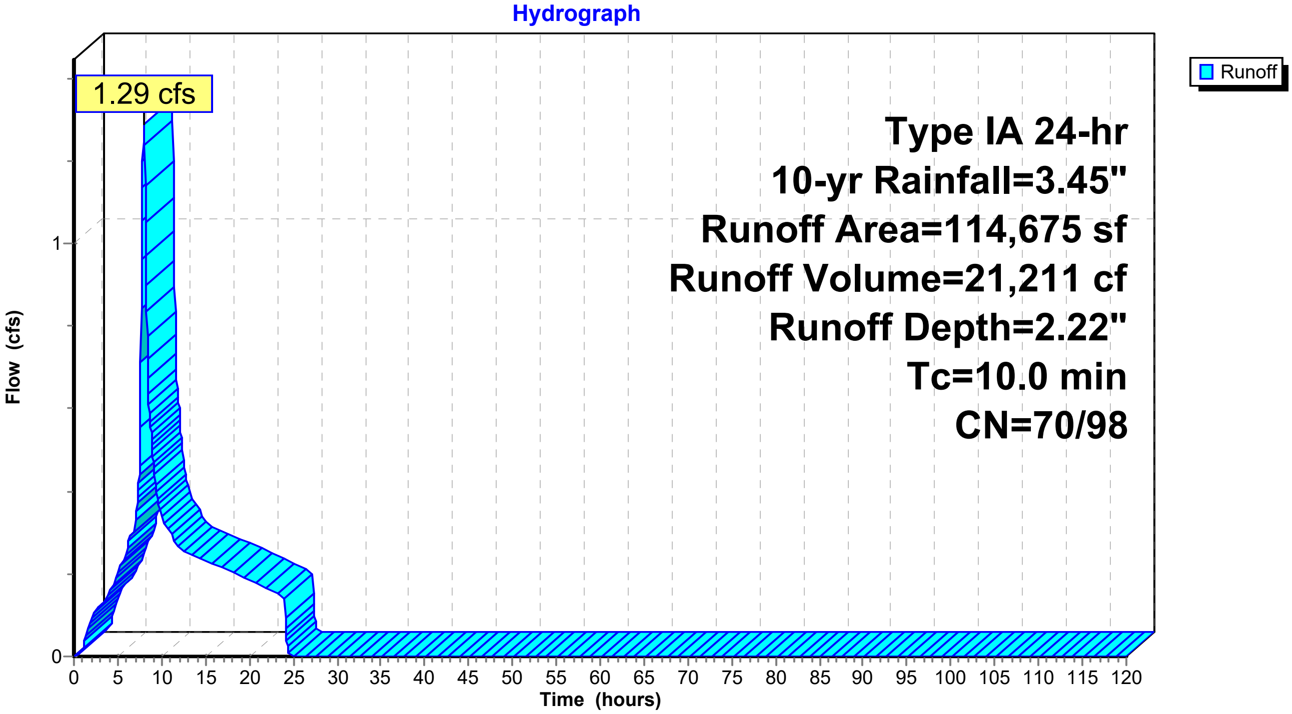
Runoff = 1.29 cfs @ 7.99 hrs, Volume= 21,211 cf, Depth= 2.22"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10-yr Rainfall=3.45"

	Area (sf)	CN	Description
*	63,615	98	
	3,514	85	Gravel roads, HSG B
	47,546	69	50-75% Grass cover, Fair, HSG B
	114,675	86	Weighted Average
	51,060	70	44.53% Pervious Area
	63,615	98	55.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 8S: N Post-developed HUD



Summary for Pond 1P: Cudo

[81] Warning: Exceeded Pond 7P by 4.53' @ 114.75 hrs
[81] Warning: Exceeded Pond 7P by 4.53' @ 114.75 hrs

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth > 2.16" for 10-yr event
Inflow = 1.11 cfs @ 8.12 hrs, Volume= 20,672 cf
Outflow = 0.22 cfs @ 17.08 hrs, Volume= 12,959 cf, Atten= 81%, Lag= 537.9 min
Primary = 0.02 cfs @ 17.08 hrs, Volume= 5,966 cf
Secondary = 0.14 cfs @ 17.08 hrs, Volume= 5,991 cf
Tertiary = 0.06 cfs @ 17.08 hrs, Volume= 1,003 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 105.48' @ 17.08 hrs Surf.Area= 3,156 sf Storage= 9,795 cf

Plug-Flow detention time= 1,709.7 min calculated for 12,959 cf (63% of inflow)
Center-of-Mass det. time= 971.7 min (2,419.0 - 1,447.3)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	13,467 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,220	0.0	0	0	2,220
101.00	2,220	30.0	666	666	2,408
103.00	2,220	95.0	4,218	4,884	2,785
103.01	1,722	20.0	4	4,888	3,283
103.51	1,722	20.0	172	5,060	3,366
106.50	4,067	100.0	8,407	13,467	5,794

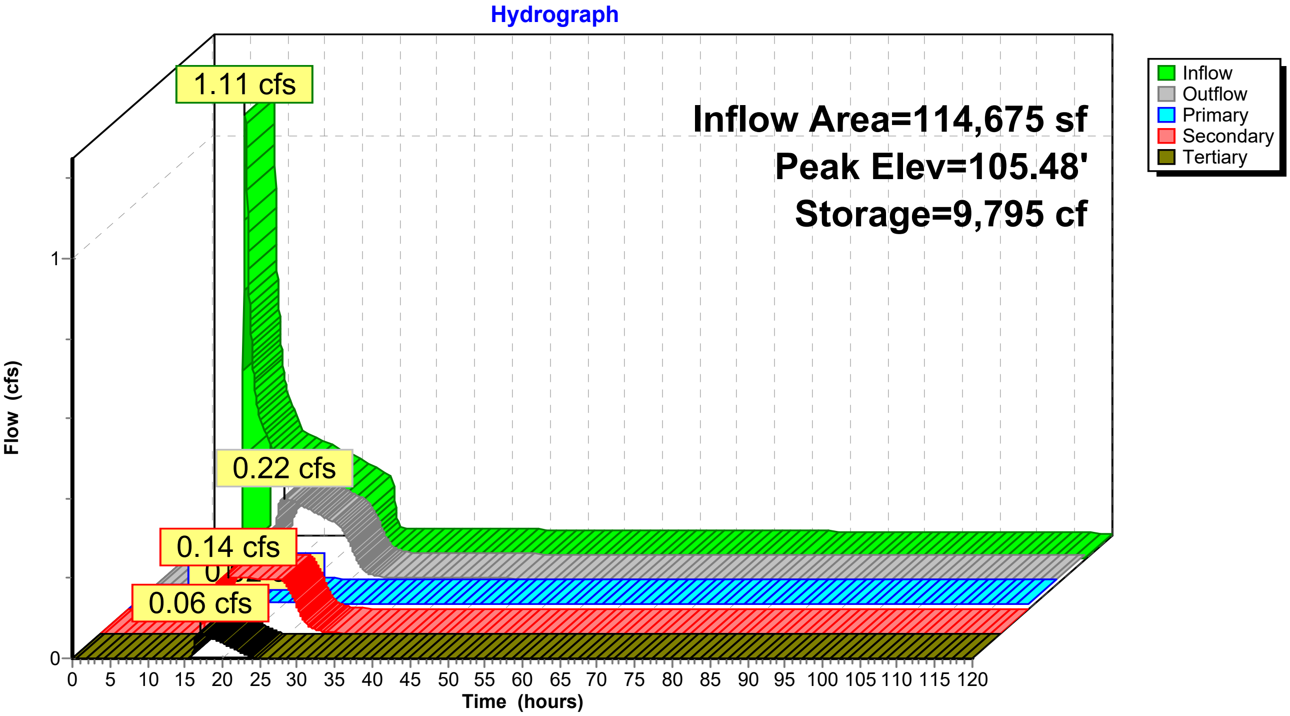
Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.50" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	105.13'	**3.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	105.45'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.02 cfs @ 17.08 hrs HW=105.48' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 11.27 fps)

Secondary OutFlow Max=0.14 cfs @ 17.08 hrs HW=105.48' (Free Discharge)
└─**2=Orifice/Grate** (Orifice Controls 0.14 cfs @ 2.85 fps)

Tertiary OutFlow Max=0.05 cfs @ 17.08 hrs HW=105.48' (Free Discharge)
└─**3=Orifice/Grate** (Weir Controls 0.05 cfs @ 0.57 fps)

Pond 1P: Cudo


Hydrograph
1.11 cfs
0.22 cfs
0.14 cfs
0.06 cfs
Inflow Area=114,675 sf
Peak Elev=105.48'
Storage=9,795 cf
🟩 Inflow
⬜ Outflow
🟦 Primary
🟥 Secondary
🟫 Tertiary
Flow (cfs)
1
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120
Time (hours)

Summary for Pond 7P: WQ

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth = 2.22" for 10-yr event
Inflow = 1.29 cfs @ 7.99 hrs, Volume= 21,211 cf
Outflow = 1.11 cfs @ 8.12 hrs, Volume= 20,672 cf, Atten= 14%, Lag= 8.0 min
Primary = 0.02 cfs @ 8.12 hrs, Volume= 5,428 cf
Secondary = 1.10 cfs @ 8.12 hrs, Volume= 15,244 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 101.92' @ 8.12 hrs Surf.Area= 3,359 sf Storage= 5,374 cf

Plug-Flow detention time= 751.5 min calculated for 20,663 cf (97% of inflow)
Center-of-Mass det. time= 735.2 min (1,447.3 - 712.2)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	9,360 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

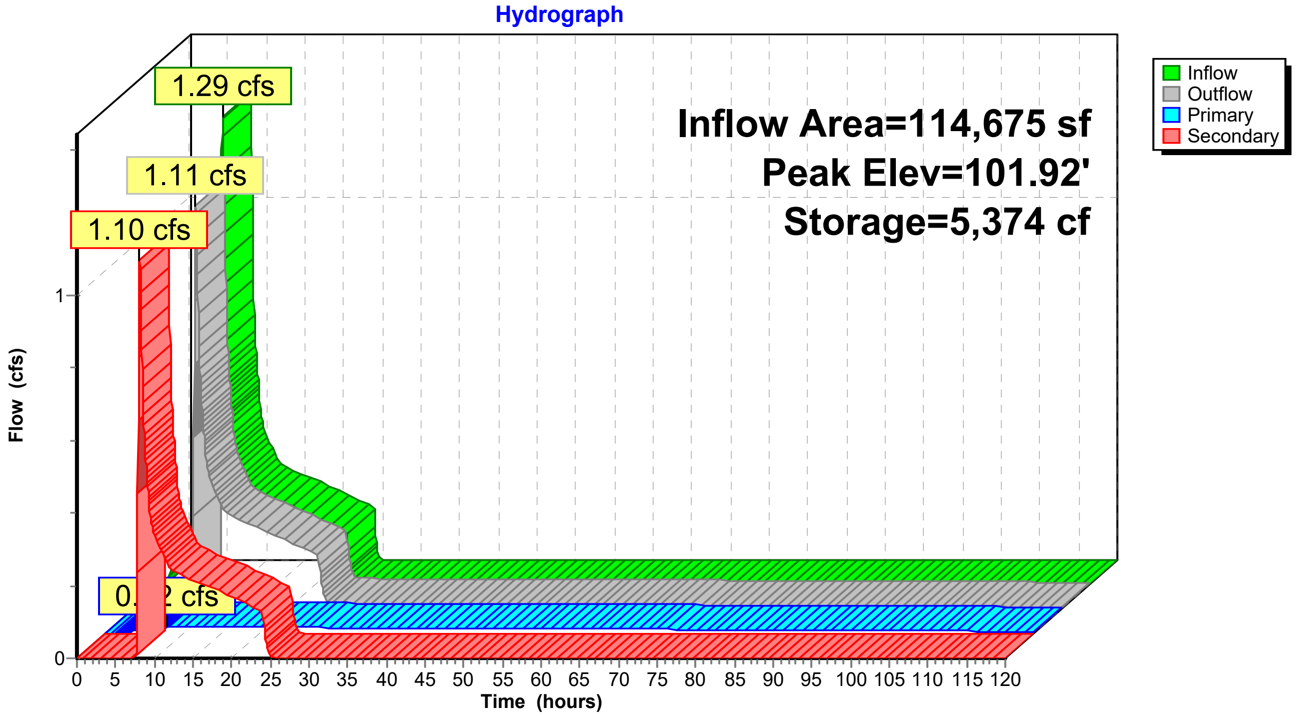
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,261	0.0	0	0	2,261
103.00	4,067	100.0	9,360	9,360	4,187

Device	Routing	Invert	Outlet Devices
#1	Primary	100.01'	**0.71" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.70'	**12.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.02 cfs @ 8.12 hrs HW=101.92' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 6.66 fps)

Secondary OutFlow Max=1.09 cfs @ 8.12 hrs HW=101.92' (Free Discharge)
└─**2=Orifice/Grate** (Weir Controls 1.09 cfs @ 1.55 fps)

Pond 7P: WQ


Hydrograph
1.29 cfs
1.11 cfs
1.10 cfs
0. 2 cfs
Inflow Area=114,675 sf
Peak Elev=101.92'
Storage=5,374 cf
Inflow
Outflow
Primary
Secondary
Flow (cfs)
1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
Time (hours)

NORTH UNMANAGED DRIVEWAY RUNOFF - 10-YEAR STORM

Summary for Subcatchment 4S: N P. Dev Drive ROW Quantity

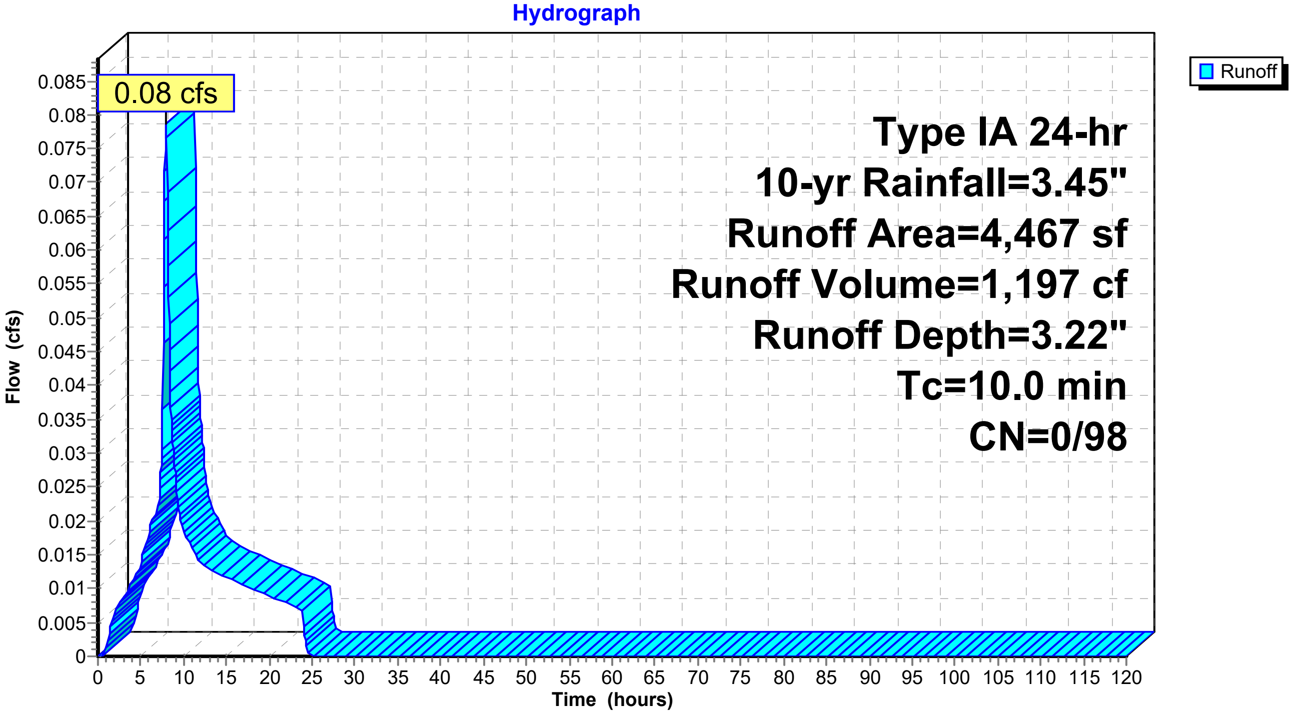
Runoff = 0.08 cfs @ 7.98 hrs, Volume= 1,197 cf, Depth= 3.22"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10-yr Rainfall=3.45"

	Area (sf)	CN	Description
*	4,467	98	New driveway
	4,467	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 4S: N P. Dev Drive ROW Quantity



NORTH TOTAL DISCHARGE FROM SITE - 10-YEAR STORM

Summary for Pond 16P: (new Pond)

[57] Hint: Peaked at 93.20' (Flood elevation advised)

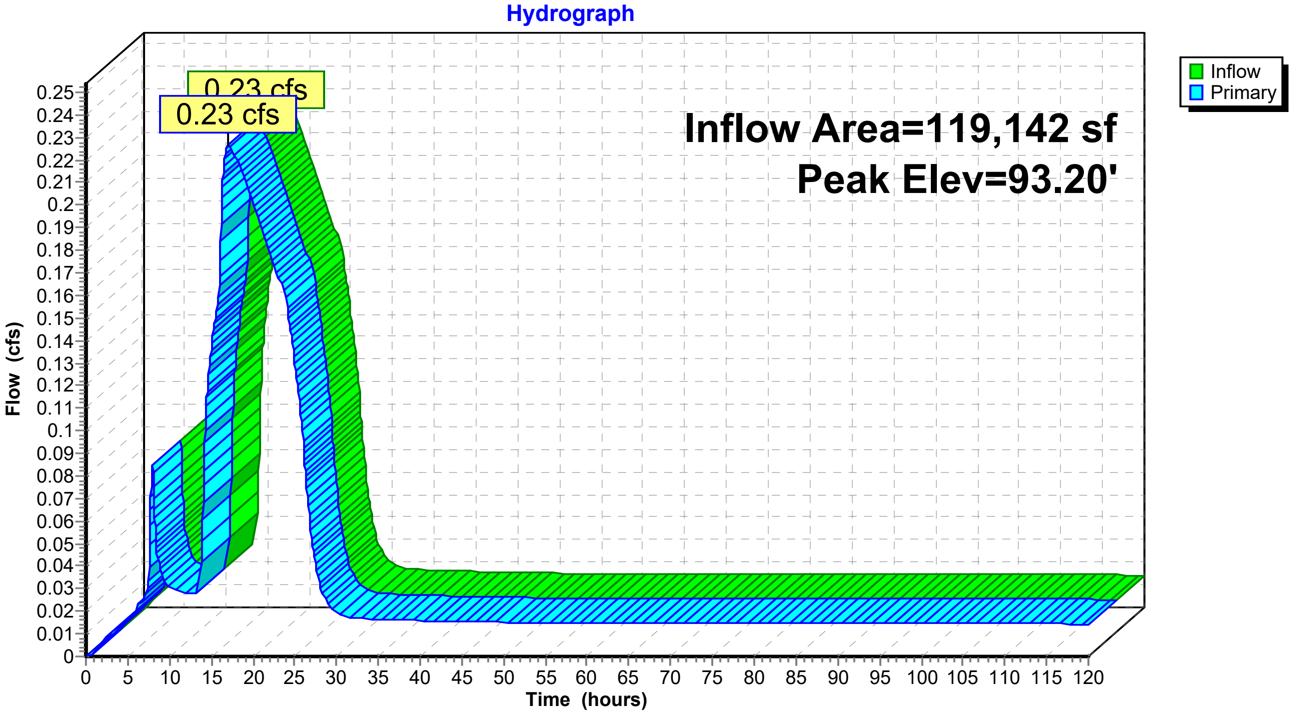
Inflow Area = 119,142 sf, 57.14% Impervious, Inflow Depth > 1.43" for 10-yr event
Inflow = 0.23 cfs @ 17.07 hrs, Volume= 14,157 cf
Outflow = 0.23 cfs @ 17.07 hrs, Volume= 14,157 cf, Atten= 0%, Lag= 0.0 min
Primary = 0.23 cfs @ 17.07 hrs, Volume= 14,157 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.20' @ 17.07 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**20.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.23 cfs @ 17.07 hrs HW=93.20' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.23 cfs @ 1.52 fps)

Pond 16P: (new Pond)



NORTH BASIN 25-YEAR STORM

Summary for Subcatchment 2S: Pre North

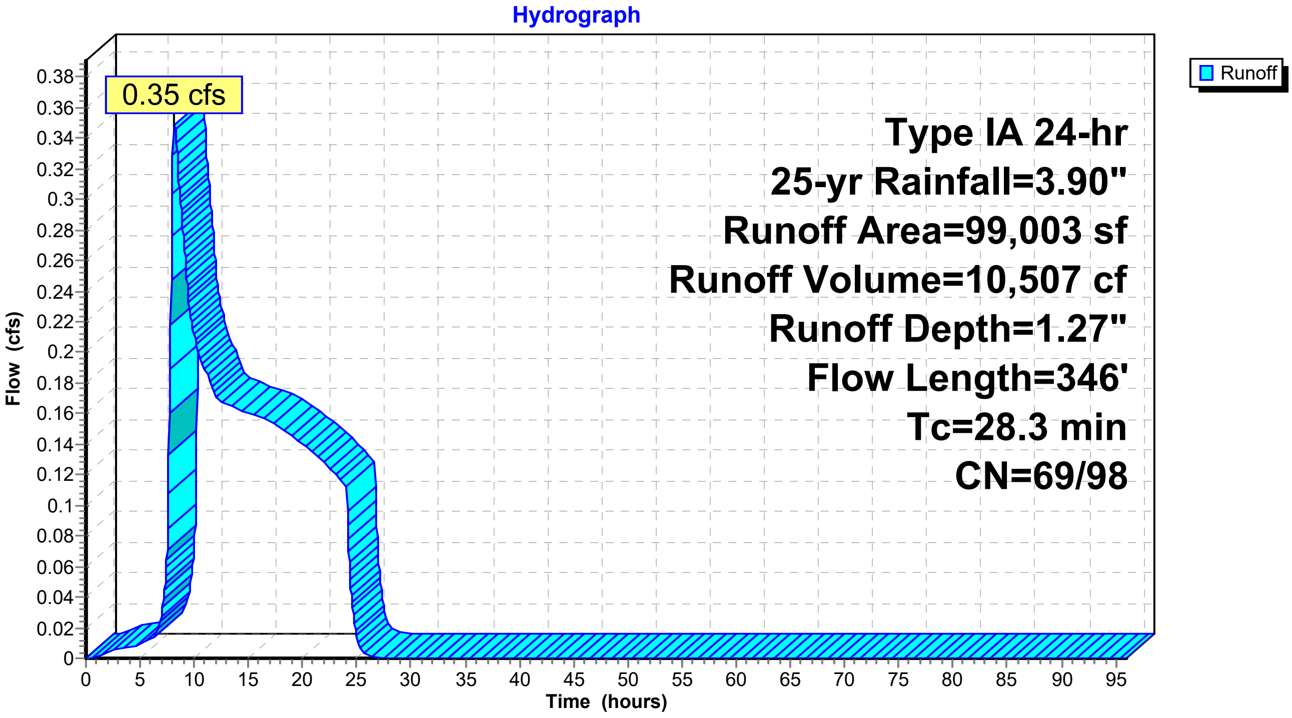
Runoff = 0.35 cfs @ 8.16 hrs, Volume= 10,507 cf, Depth= 1.27"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-yr Rainfall=3.90"

Area (sf)	CN	Description
860	85	Gravel roads, HSG B
450	98	Paved parking, HSG B
2,422	98	Roofs, HSG B
92,895	69	Pasture/grassland/range, Fair, HSG B
2,376	69	Pasture/grassland/range, Fair, HSG B
99,003	70	Weighted Average
96,131	69	97.10% Pervious Area
2,872	98	2.90% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
28.1	300	0.0450	0.18		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.2	46	0.0650	3.82		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
28.3	346	Total			

Subcatchment 2S: Pre North



NORTH POST-DEVELOPED BASIN RUNOFF - 25-YEAR STORM

Summary for Subcatchment 8S: N Post-developed HUD

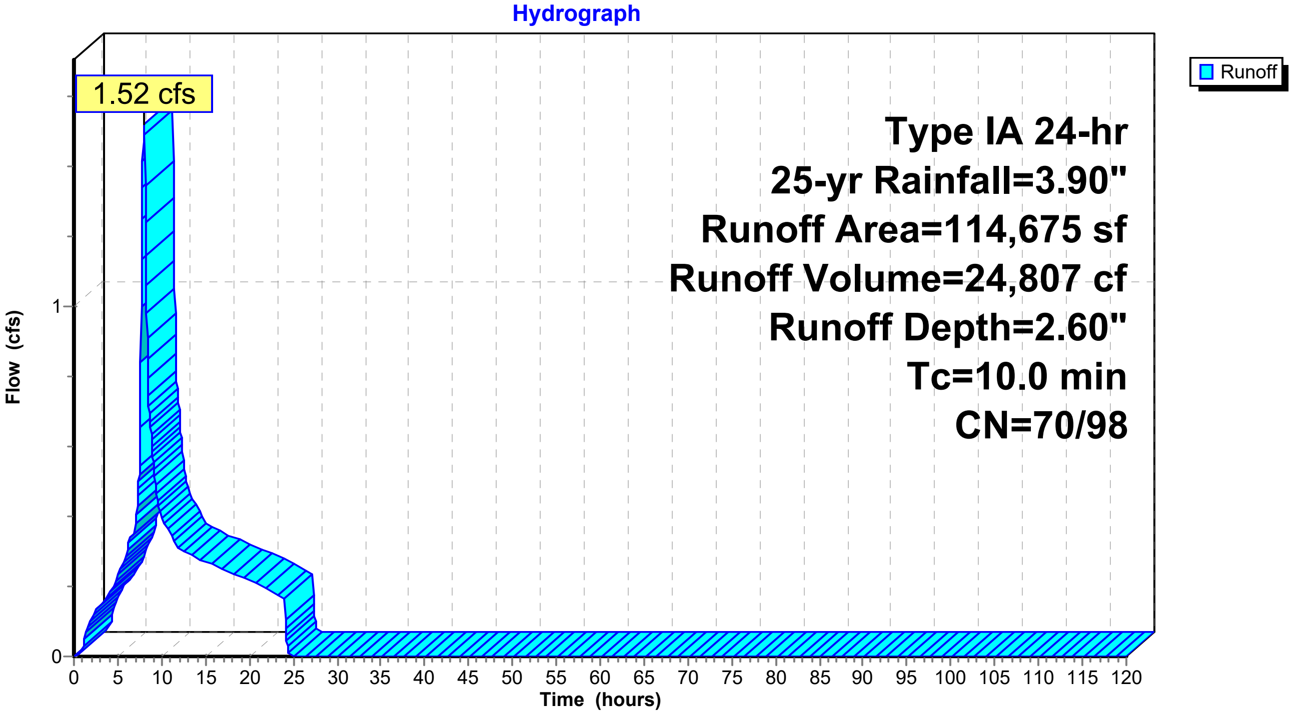
Runoff = 1.52 cfs @ 7.99 hrs, Volume= 24,807 cf, Depth= 2.60"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-yr Rainfall=3.90"

	Area (sf)	CN	Description
*	63,615	98	
	3,514	85	Gravel roads, HSG B
	47,546	69	50-75% Grass cover, Fair, HSG B
	114,675	86	Weighted Average
	51,060	70	44.53% Pervious Area
	63,615	98	55.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 8S: N Post-developed HUD



Summary for Pond 1P: Cudo

[81] Warning: Exceeded Pond 7P by 4.53' @ 114.75 hrs
[81] Warning: Exceeded Pond 7P by 4.53' @ 114.75 hrs

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth > 2.54" for 25-yr event
Inflow = 1.42 cfs @ 8.07 hrs, Volume= 24,267 cf
Outflow = 0.28 cfs @ 13.90 hrs, Volume= 16,553 cf, Atten= 80%, Lag= 350.0 min
Primary = 0.02 cfs @ 13.90 hrs, Volume= 6,002 cf
Secondary = 0.14 cfs @ 13.90 hrs, Volume= 7,415 cf
Tertiary = 0.12 cfs @ 13.90 hrs, Volume= 3,136 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 105.50' @ 13.90 hrs Surf.Area= 3,176 sf Storage= 9,871 cf

Plug-Flow detention time= 1,383.3 min calculated for 16,546 cf (68% of inflow)
Center-of-Mass det. time= 753.7 min (2,096.7 - 1,343.0)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	13,467 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,220	0.0	0	0	2,220
101.00	2,220	30.0	666	666	2,408
103.00	2,220	95.0	4,218	4,884	2,785
103.01	1,722	20.0	4	4,888	3,283
103.51	1,722	20.0	172	5,060	3,366
106.50	4,067	100.0	8,407	13,467	5,794

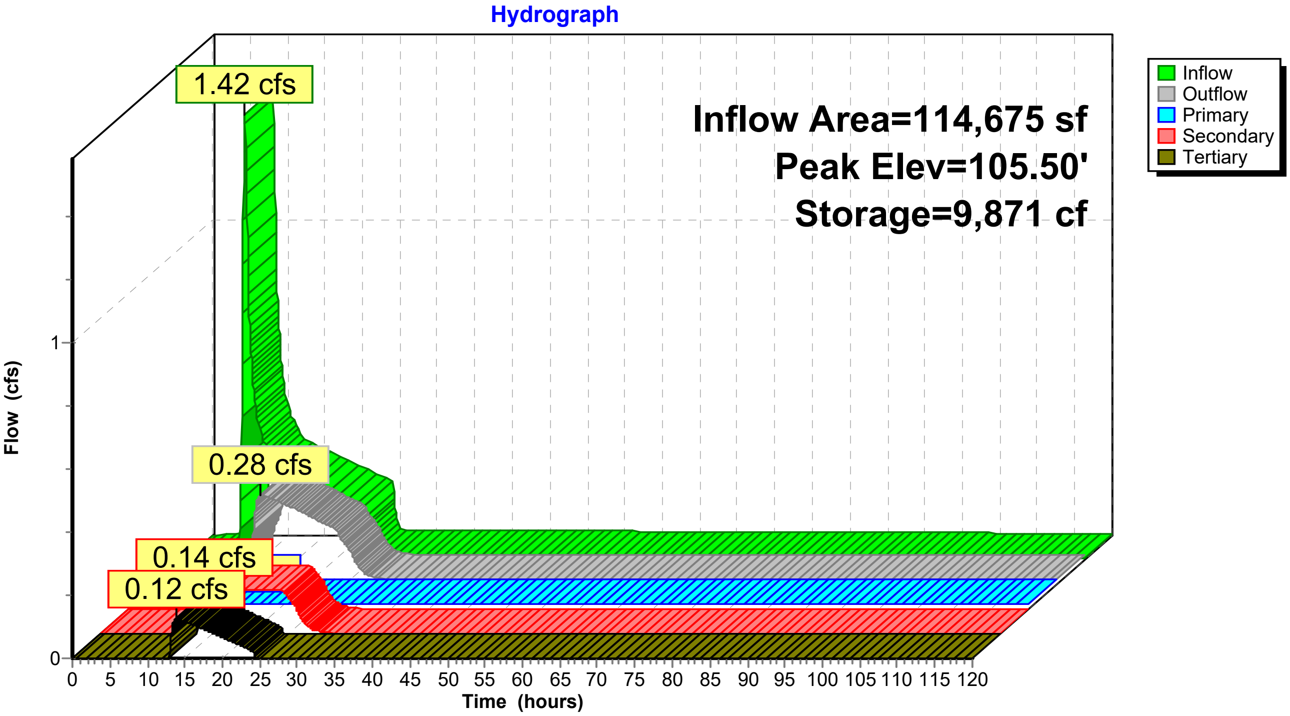
Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.50" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	105.13'	**3.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	105.45'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.02 cfs @ 13.90 hrs HW=105.50' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 11.30 fps)

Secondary OutFlow Max=0.14 cfs @ 13.90 hrs HW=105.50' (Free Discharge)
↑—**2=Orifice/Grate** (Orifice Controls 0.14 cfs @ 2.95 fps)

Tertiary OutFlow Max=0.11 cfs @ 13.90 hrs HW=105.50' (Free Discharge)
↑—**3=Orifice/Grate** (Weir Controls 0.11 cfs @ 0.76 fps)

Pond 1P: Cudo


Hydrograph
1.42 cfs
0.28 cfs
0.14 cfs
0.12 cfs
Inflow Area=114,675 sf
Peak Elev=105.50'
Storage=9,871 cf
Inflow
Outflow
Primary
Secondary
Tertiary
Flow (cfs)
0
1
Time (hours)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

Summary for Pond 7P: WQ

Inflow Area = 114,675 sf, 55.47% Impervious, Inflow Depth = 2.60" for 25-yr event
Inflow = 1.52 cfs @ 7.99 hrs, Volume= 24,807 cf
Outflow = 1.42 cfs @ 8.07 hrs, Volume= 24,267 cf, Atten= 7%, Lag= 5.1 min
Primary = 0.02 cfs @ 8.07 hrs, Volume= 5,453 cf
Secondary = 1.40 cfs @ 8.07 hrs, Volume= 18,814 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 101.96' @ 8.07 hrs Surf.Area= 3,384 sf Storage= 5,507 cf

Plug-Flow detention time= 646.4 min calculated for 24,257 cf (98% of inflow)
Center-of-Mass det. time= 632.6 min (1,343.0 - 710.4)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	9,360 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

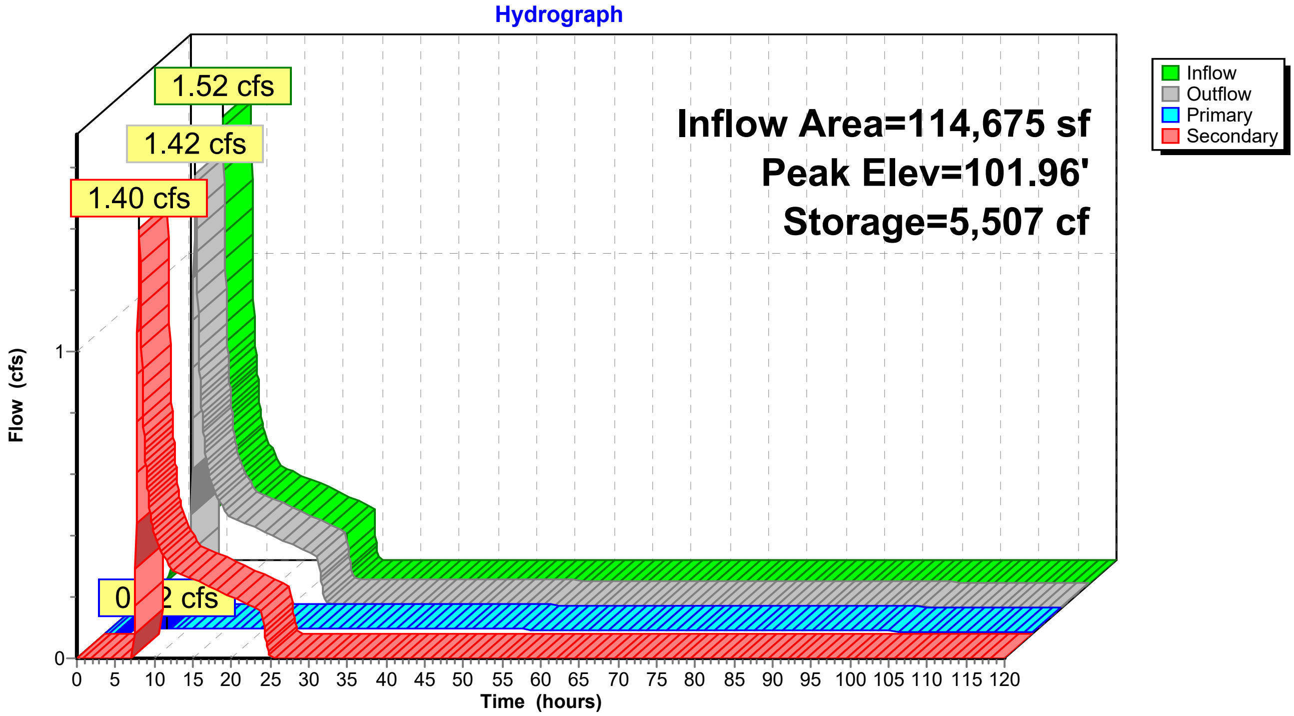
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	2,261	0.0	0	0	2,261
103.00	4,067	100.0	9,360	9,360	4,187

Device	Routing	Invert	Outlet Devices
#1	Primary	100.01'	**0.71" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.70'	**12.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.02 cfs @ 8.07 hrs HW=101.96' (Free Discharge)
↑└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 6.73 fps)

Secondary OutFlow Max=1.39 cfs @ 8.07 hrs HW=101.96' (Free Discharge)
↑└─**2=Orifice/Grate** (Weir Controls 1.39 cfs @ 1.68 fps)

Pond 7P: WQ


Hydrograph
1.52 cfs
1.42 cfs
1.40 cfs
0 2 cfs
Inflow Area=114,675 sf
Peak Elev=101.96'
Storage=5,507 cf
Inflow
Outflow
Primary
Secondary
Flow (cfs)
0
1
Time (hours)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

Summary for Subcatchment 4S: N P. Dev Drive ROW Quantity

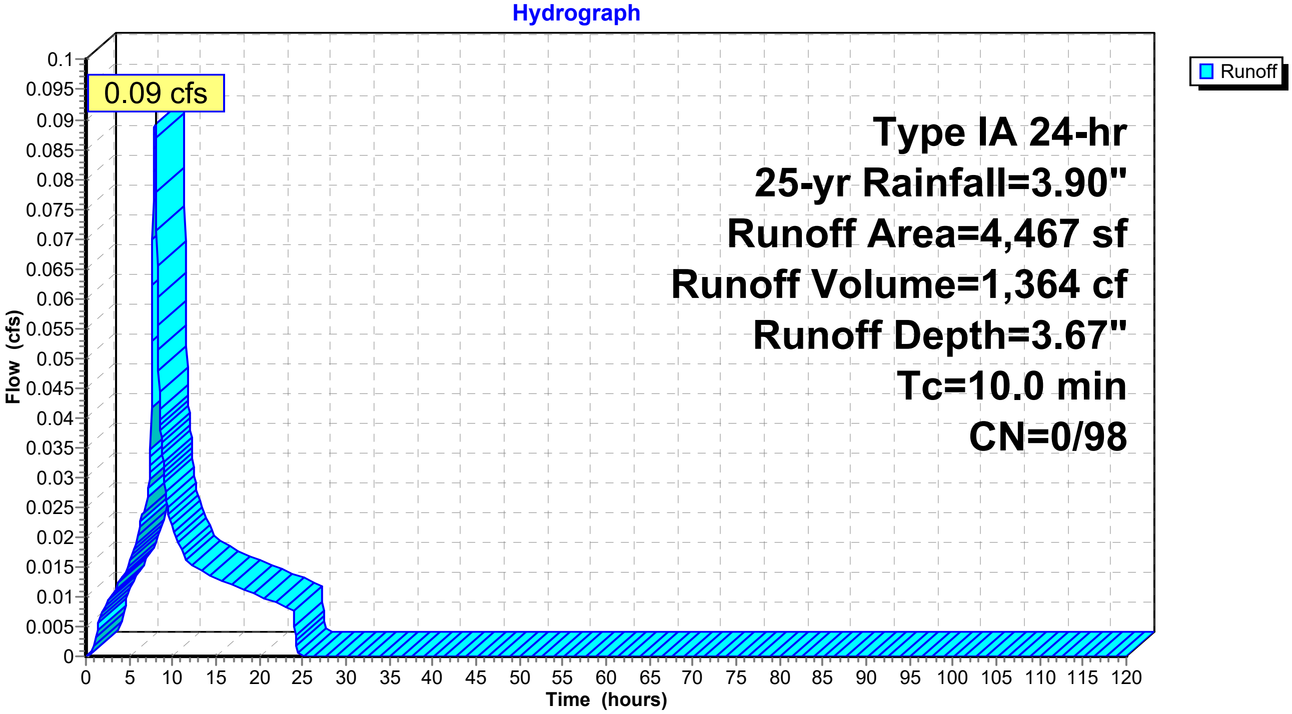
Runoff = 0.09 cfs @ 7.98 hrs, Volume= 1,364 cf, Depth= 3.67"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-yr Rainfall=3.90"

	Area (sf)	CN	Description
*	4,467	98	New driveway
	4,467	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 4S: N P. Dev Drive ROW Quantity



Summary for Pond 16P: (new Pond)

[57] Hint: Peaked at 93.23' (Flood elevation advised)

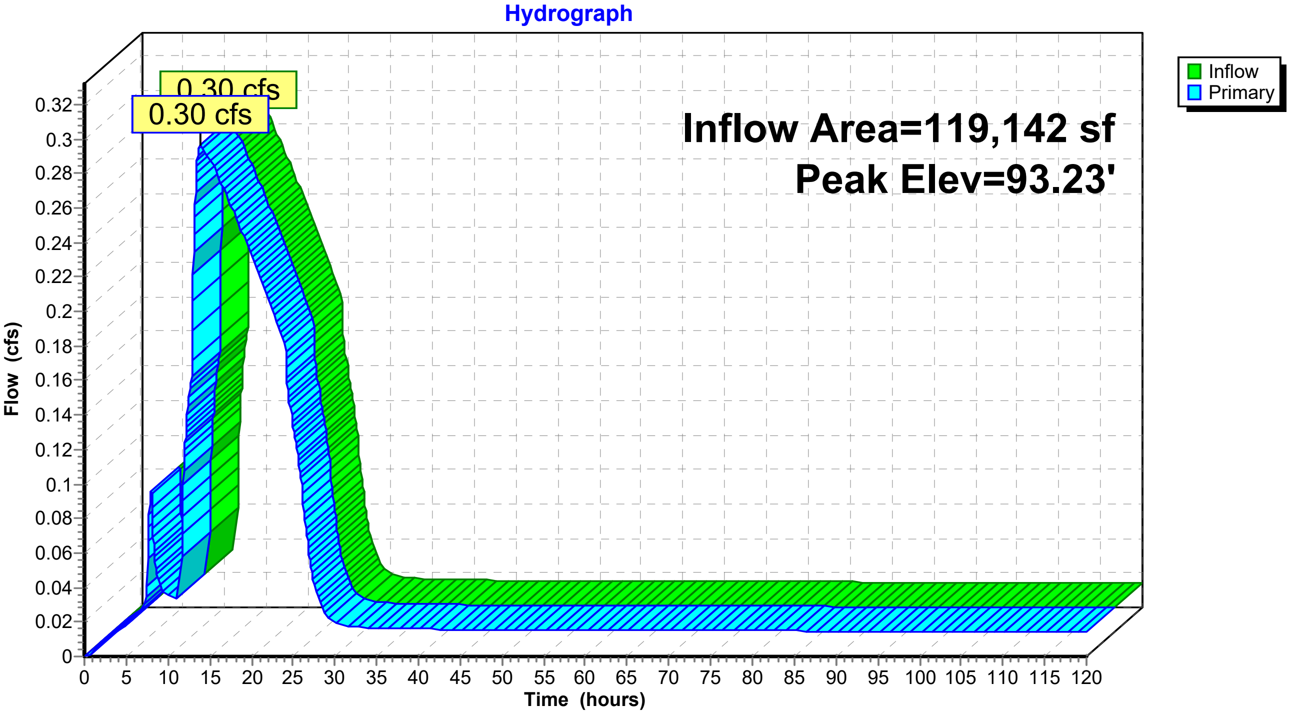
```
Inflow Area =          119,142 sf,  57.14% Impervious,  Inflow Depth >   1.80"    for  25-yr event
Inflow      =         0.30 cfs @   13.89 hrs,  Volume=           17,917 cf
Outflow     =         0.30 cfs @   13.89 hrs,  Volume=           17,917 cf,  Atten= 0%,  Lag= 0.0 min
Primary     =         0.30 cfs @   13.89 hrs,  Volume=           17,917 cf
```

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.23' @ 13.89 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**20.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.30 cfs @ 13.89 hrs HW=93.23' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.30 cfs @ 1.63 fps)

Pond 16P: (new Pond)



NORTH BASIN WQ-HUD STORM

NORTH POST-DEVELOPED BASIN RUNOFF - WQ-HUD STORM

Summary for Subcatchment 8S: N Post-developed HUD

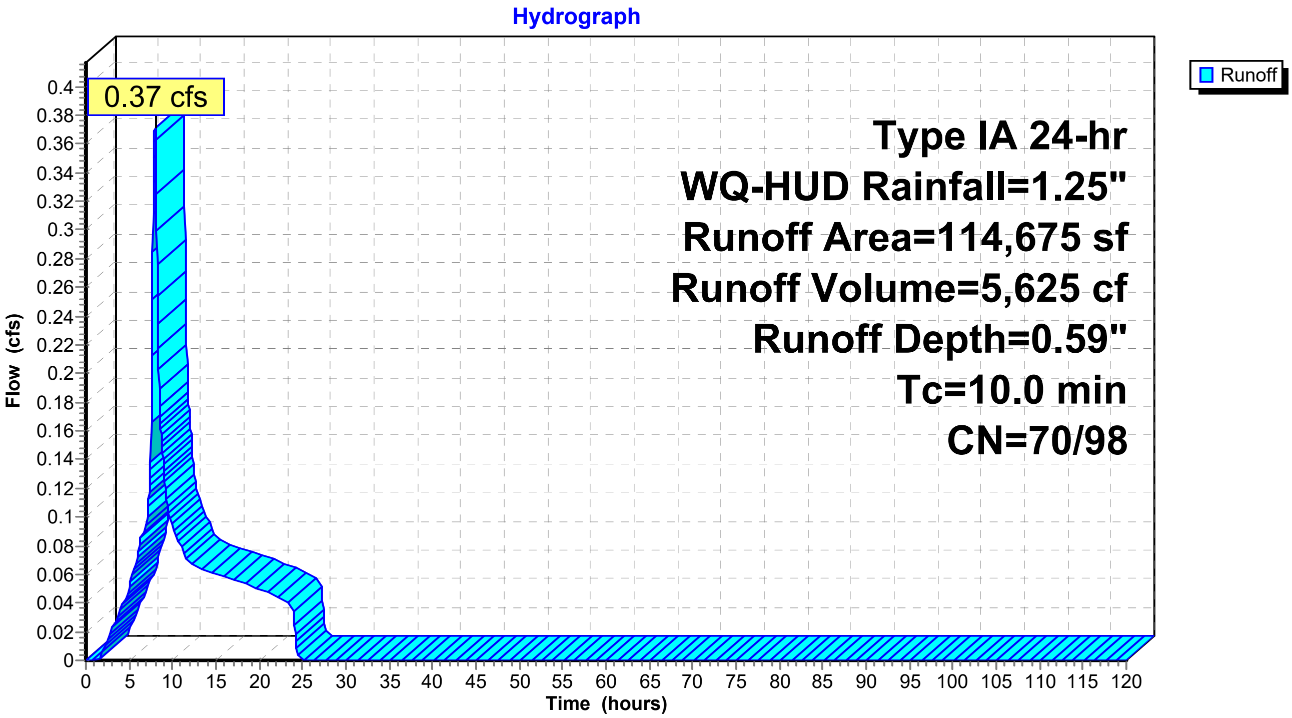
Runoff = 0.37 cfs @ 7.98 hrs, Volume= 5,625 cf, Depth= 0.59"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr WQ-HUD Rainfall=1.25"

	Area (sf)	CN	Description
*	63,615	98	
	3,514	85	Gravel roads, HSG B
	47,546	69	50-75% Grass cover, Fair, HSG B
	114,675	86	Weighted Average
	51,060	70	44.53% Pervious Area
	63,615	98	55.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

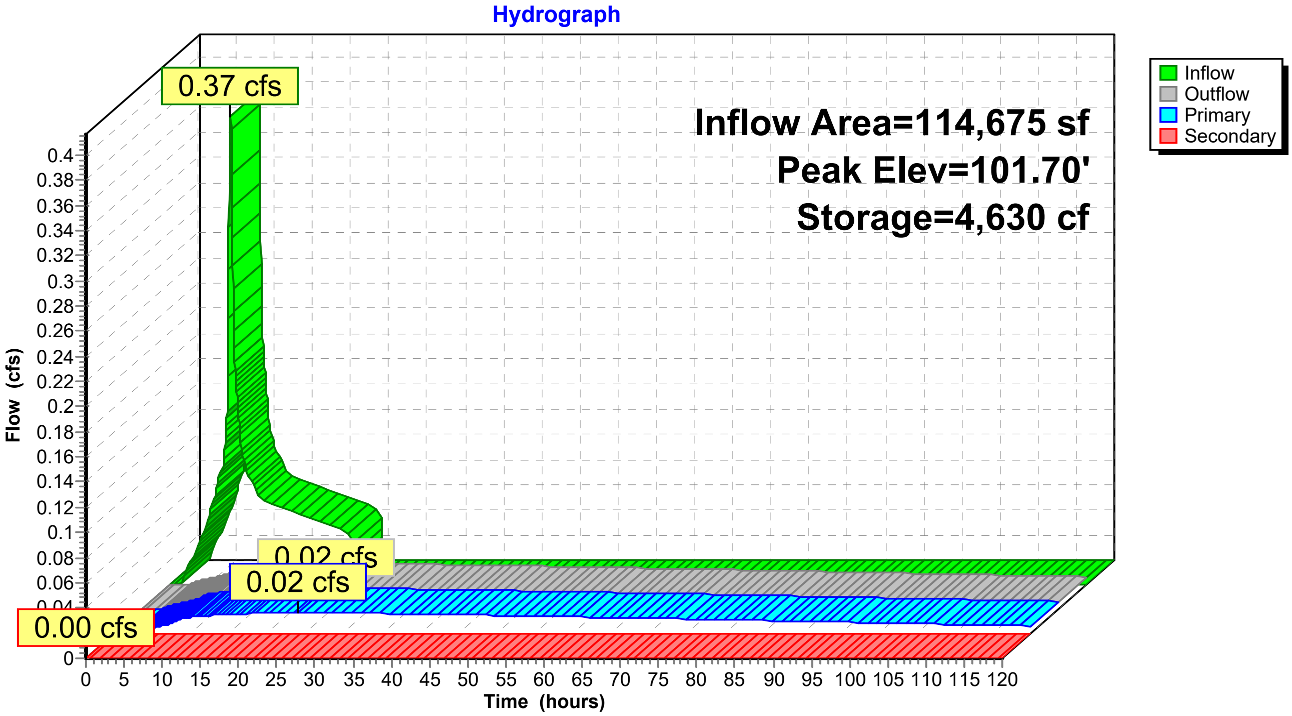
Subcatchment 8S: N Post-developed HUD



Summary for Pond 7P: WQ

```
Inflow Area =        114,675 sf, 55.47% Impervious,  Inflow Depth =  0.59"   for  WQ-HUD event
Inflow      =       0.37 cfs @    7.98 hrs,  Volume=          5,625 cf
Outflow     =       0.02 cfs @   24.16 hrs,  Volume=          5,108 cf,  Atten= 95%,  Lag= 971.0 min
Primary     =       0.02 cfs @   24.16 hrs,  Volume=          5,108 cf
Secondary   =       0.00 cfs @    0.00 hrs,  Volume=              0 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 101.70' @ 24.16 hrs   Surf.Area= 3,219 sf   Storage= 4,630 cf

Plug-Flow detention time= 2,654.6 min calculated for 5,106 cf (91% of inflow)
Center-of-Mass det. time= 2,592.3 min ( 3,311.1 - 718.8 )

Volume        Invert    Avail.Storage   Storage Description
   #1        100.00'         9,360 cf   Custom Stage Data (Pyramidal)Listed below (Recalc)

 Elevation        Surf.Area   Voids        Inc.Store      Cum.Store        Wet.Area
    (feet)           (sq-ft)    (%)     (cubic-feet)   (cubic-feet)          (sq-ft)
    100.00             2,261    0.0                0              0            2,261
    103.00             4,067  100.0            9,360          9,360            4,187

Device   Routing           Invert   Outlet Devices
  #1     Primary          100.01'   0.71" Horiz. Orifice/Grate   C= 0.600
                                    Limited to weir flow at low heads
  #2     Secondary        101.70'   12.00" Horiz. Orifice/Grate   C= 0.600
                                    Limited to weir flow at low heads

Primary OutFlow  Max=0.02 cfs @ 24.16 hrs  HW=101.70'   (Free Discharge)
└─1=Orifice/Grate  (Orifice Controls 0.02 cfs @ 6.26 fps)

Secondary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=100.00'   (Free Discharge)
└─2=Orifice/Grate  ( Controls 0.00 cfs)
```

Pond 7P: WQ


Hydrograph
0.37 cfs
0.02 cfs
0.02 cfs
0.00 cfs
Inflow Area=114,675 sf
Peak Elev=101.70'
Storage=4,630 cf
🟩 Inflow
▨ Outflow
🟦 Primary
🟥 Secondary
Flow (cfs)
0.4
0.38
0.36
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
Time (hours)

Summary for Pond 16P: (new Pond)

[57] Hint: Peaked at 93.07' (Flood elevation advised)

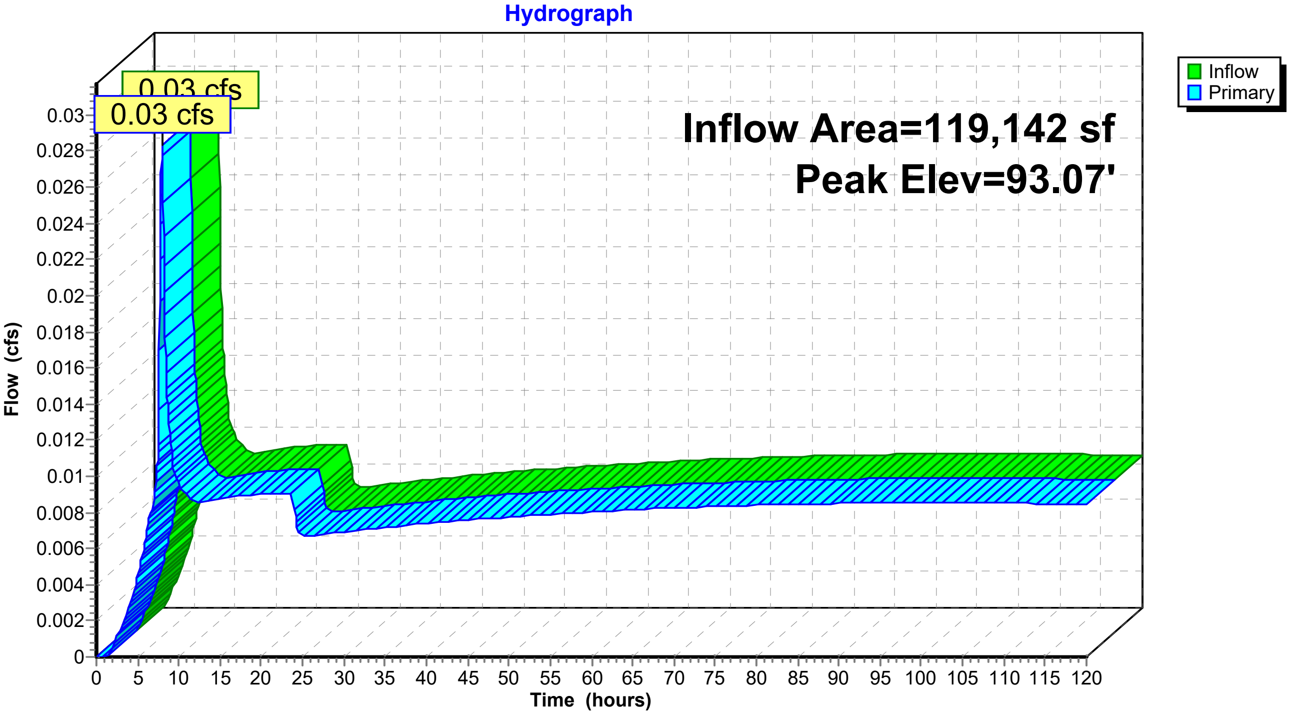
Inflow Area = 119,142 sf, 57.14% Impervious, Inflow Depth > 0.35" for WQ-HUD event
Inflow = 0.03 cfs @ 7.98 hrs, Volume= 3,456 cf
Outflow = 0.03 cfs @ 7.98 hrs, Volume= 3,456 cf, Atten= 0%, Lag= 0.0 min
Primary = 0.03 cfs @ 7.98 hrs, Volume= 3,456 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.07' @ 7.98 hrs

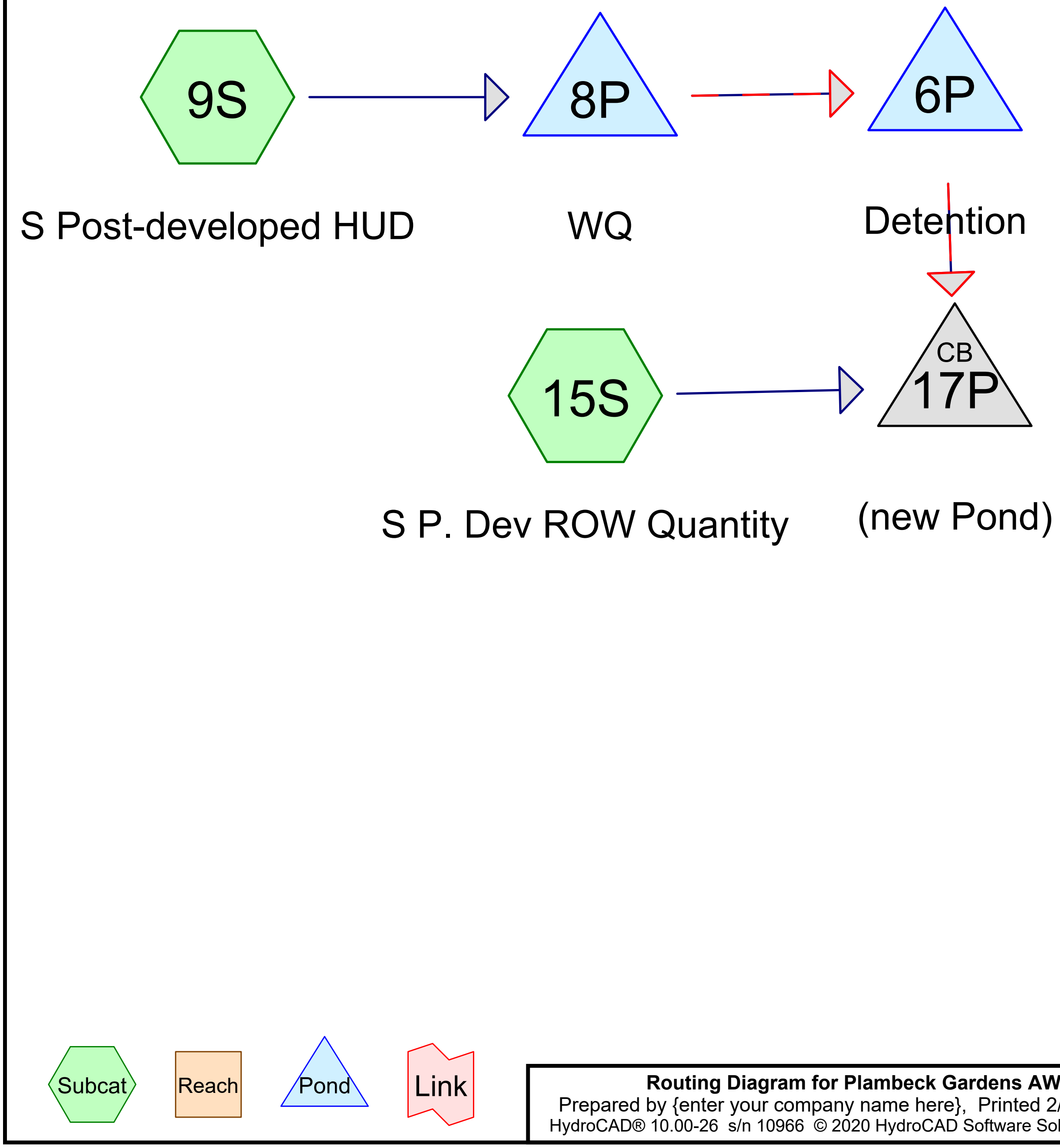
Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**20.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.03 cfs @ 7.98 hrs HW=93.07' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.03 cfs @ 0.90 fps)

Pond 16P: (new Pond)



SOUTH BASIN ROUTING DIAGRAM



Routing Diagram for Plambeck Gardens AW
Prepared by {enter your company name here}, Printed 2/25/2022
HydroCAD® 10.00-26 s/n 10966 © 2020 HydroCAD Software Solutions LLC

SOUTH BASIN 2-YEAR STORM

SOUTH PRE-DEVELOPED 2-YEAR STORM

Summary for Subcatchment 3S: Pre South

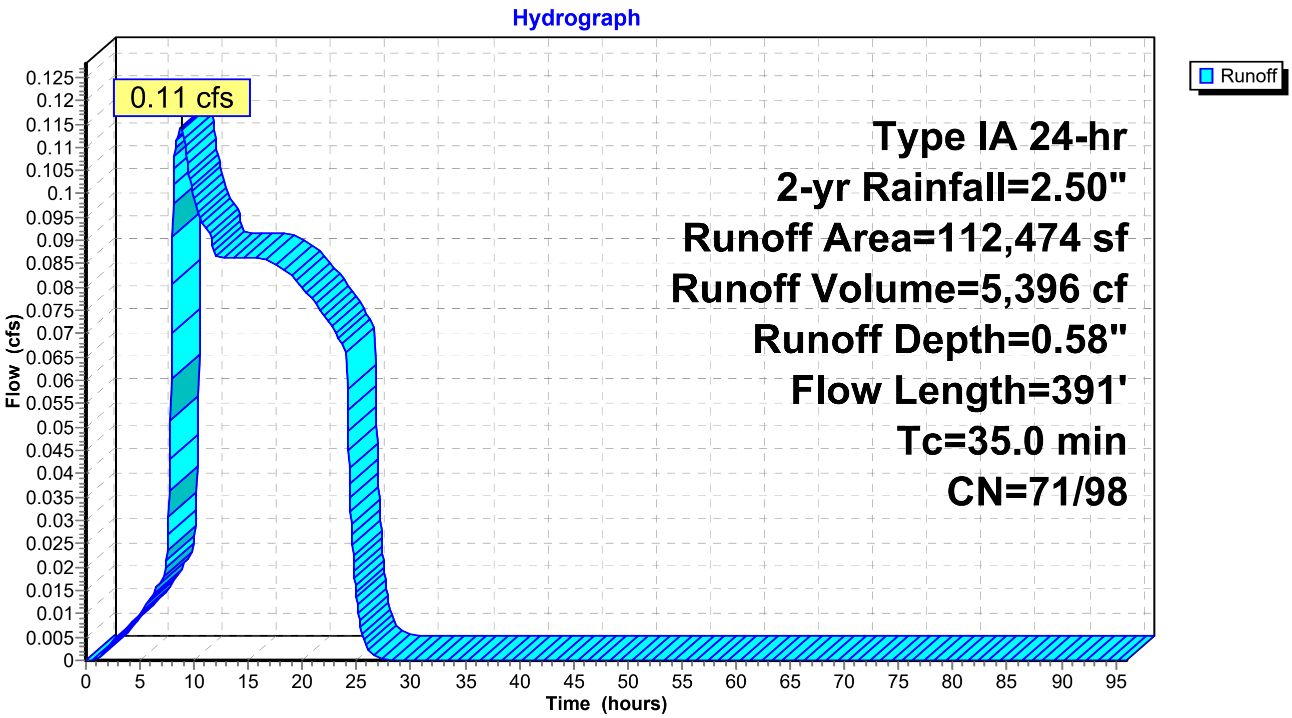
Runoff = 0.11 cfs @ 8.79 hrs, Volume= 5,396 cf, Depth= 0.58"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2-yr Rainfall=2.50"

Area (sf)	CN	Description
10,143	85	Gravel roads, HSG B
622	98	Paved parking, HSG B
4,723	98	Roofs, HSG B
95,727	69	Pasture/grassland/range, Fair, HSG B
1,259	69	Pasture/grassland/range, Fair, HSG B
112,474	72	Weighted Average
107,129	71	95.25% Pervious Area
5,345	98	4.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.6	300	0.0267	0.14		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.4	91	0.0570	3.58		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
35.0	391	Total			

Subcatchment 3S: Pre South



SOUTH POST-DEVELOPED BASIN RUNOFF - 2-YEAR STORM

Summary for Subcatchment 9S: S Post-developed HUD

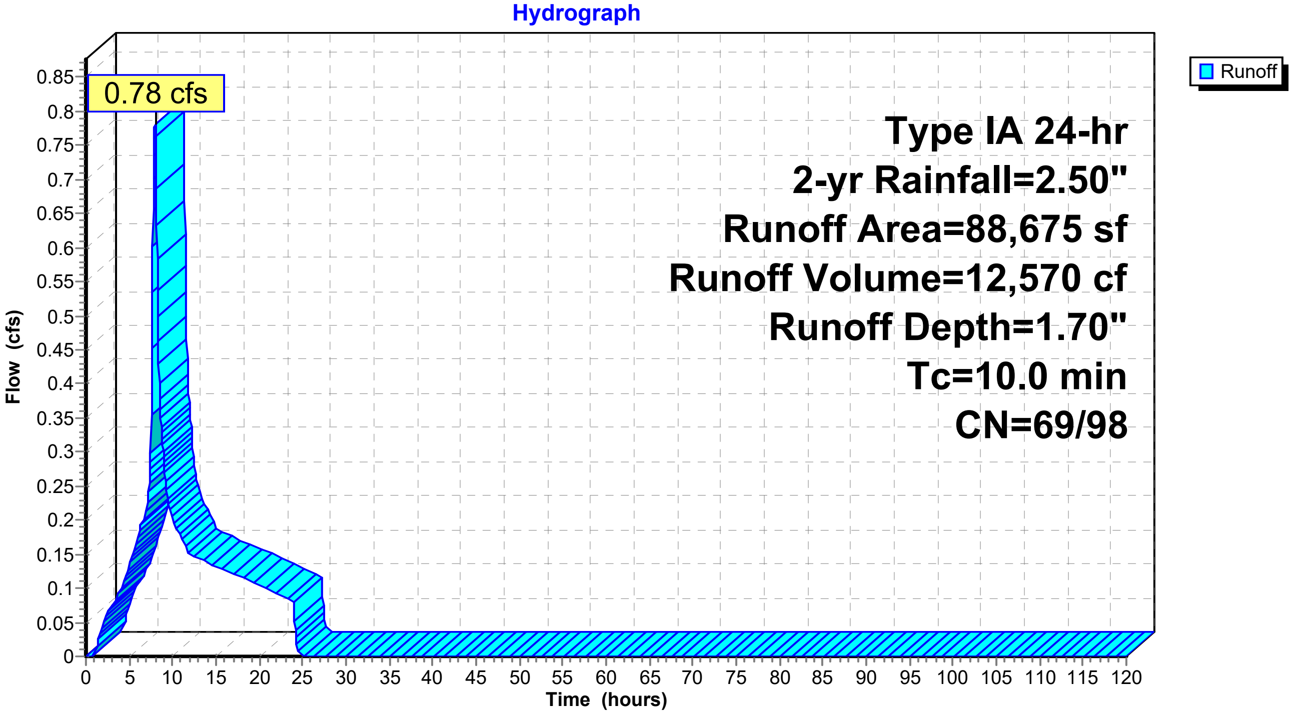
Runoff = 0.78 cfs @ 7.98 hrs, Volume= 12,570 cf, Depth= 1.70"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2-yr Rainfall=2.50"

	Area (sf)	CN	Description
*	61,366	98	
	27,309	69	50-75% Grass cover, Fair, HSG B
	88,675	89	Weighted Average
	27,309	69	30.80% Pervious Area
	61,366	98	69.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 9S: S Post-developed HUD



Summary for Pond 6P: Detention

Inflow Area = 88,675 sf, 69.20% Impervious, Inflow Depth > 1.67" for 2-yr event
Inflow = 0.23 cfs @ 9.41 hrs, Volume= 12,347 cf
Outflow = 0.05 cfs @ 24.65 hrs, Volume= 12,319 cf, Atten= 77%, Lag= 914.3 min
Primary = 0.05 cfs @ 24.65 hrs, Volume= 12,319 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 97.54' @ 24.65 hrs Surf.Area= 3,173 sf Storage= 5,167 cf

Plug-Flow detention time= 893.8 min calculated for 12,319 cf (100% of inflow)
Center-of-Mass det. time= 882.1 min (2,784.8 - 1,902.7)

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	10,759 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

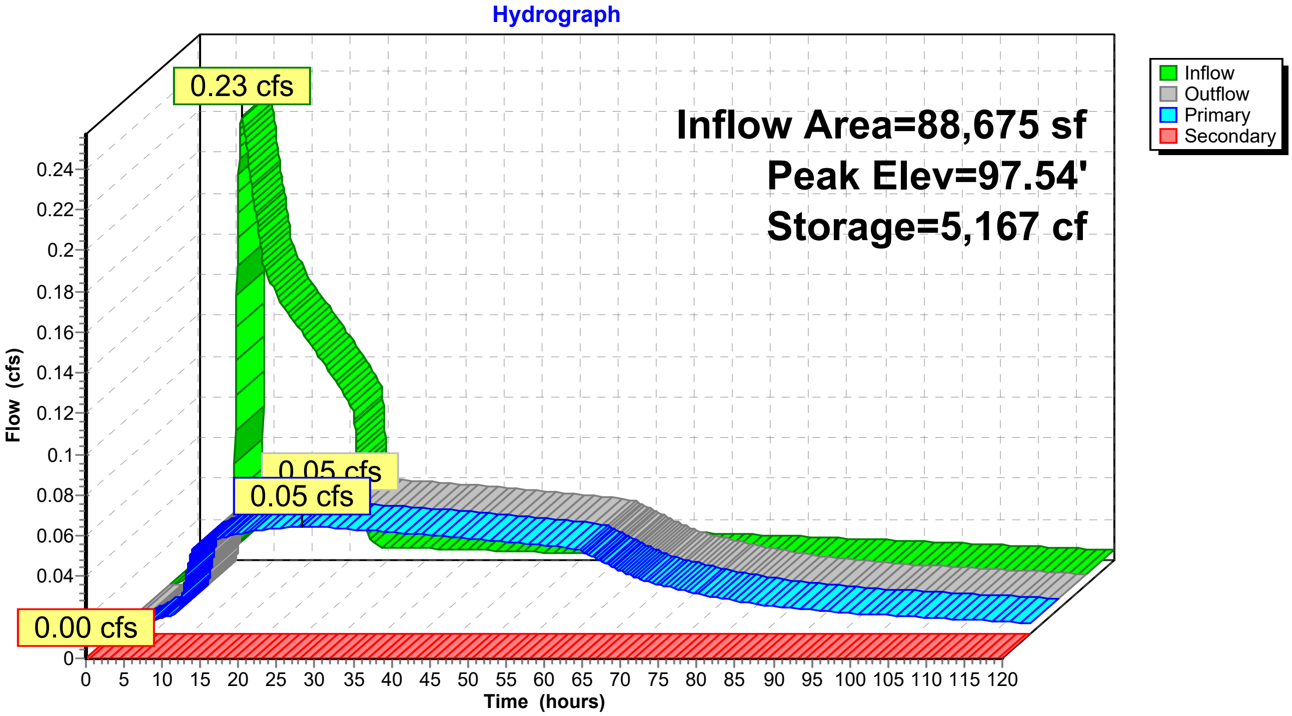
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
93.50	2,016	0.0	0	0	2,016
94.50	2,016	30.0	605	605	2,196
96.00	2,016	20.0	605	1,210	2,465
99.00	4,516	100.0	9,549	10,759	5,054

Device	Routing	Invert	Outlet Devices
#1	Primary	93.50'	**1.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	97.54'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.05 cfs @ 24.65 hrs HW=97.54' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.05 cfs @ 9.68 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=93.50' (Free Discharge)
↑**2=Orifice/Grate** (Controls 0.00 cfs)

Pond 6P: Detention



Summary for Pond 8P: WQ

```
Inflow Area =         88,675 sf,  69.20% Impervious,  Inflow Depth =   1.70"    for  2-yr event
Inflow      =      0.78 cfs @    7.98 hrs,  Volume=           12,570 cf
Outflow     =      0.23 cfs @    9.41 hrs,  Volume=           12,347 cf,  Atten= 71%,  Lag= 85.5 min
Primary     =      0.02 cfs @    9.41 hrs,  Volume=            5,601 cf
Secondary =        0.21 cfs @    9.41 hrs,  Volume=            6,745 cf
```

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 102.05' @ 9.41 hrs Surf.Area= 3,141 sf Storage= 4,965 cf

Plug-Flow detention time= 1,214.0 min calculated for 12,341 cf (98% of inflow)
Center-of-Mass det. time= 1,202.8 min (1,902.7 - 699.9)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	8,299 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

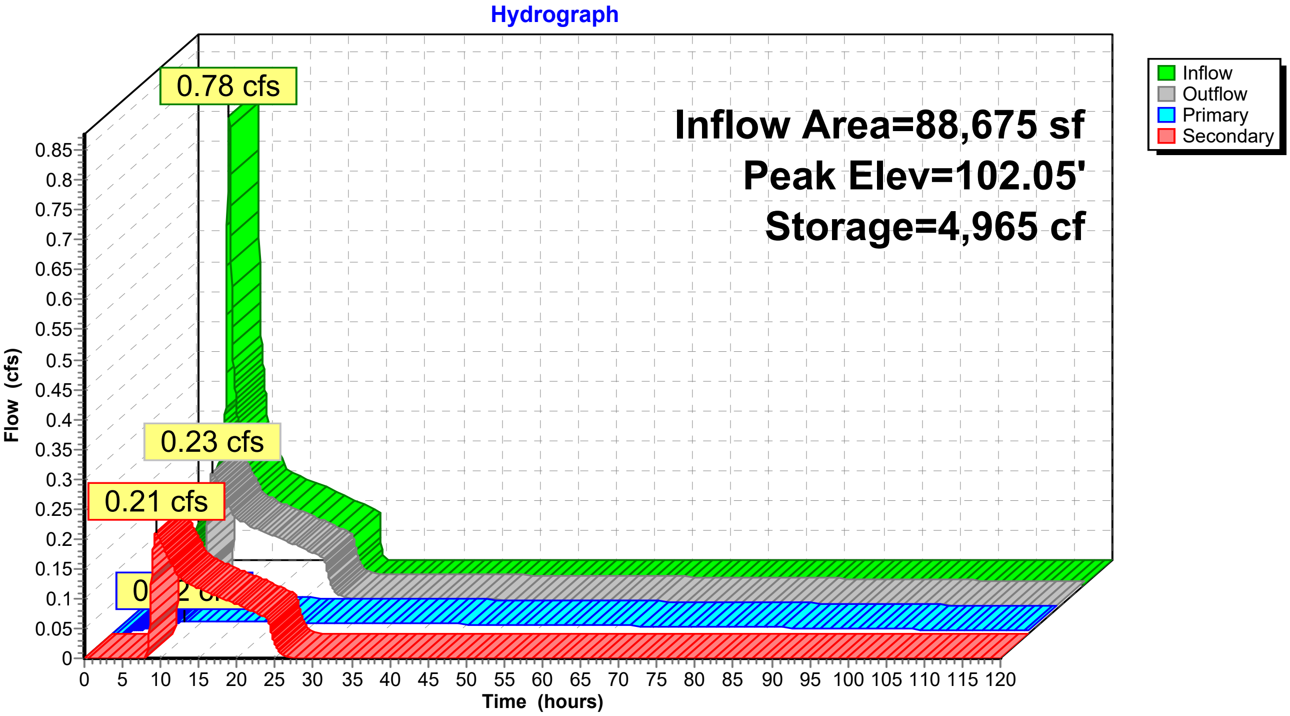
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	1,763	0.0	0	0	1,763
103.00	3,910	100.0	8,299	8,299	4,000

Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.72" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.83'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.02 cfs @ 9.41 hrs HW=102.05' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 6.90 fps)

Secondary OutFlow Max=0.21 cfs @ 9.41 hrs HW=102.05' (Free Discharge)
└─**2=Orifice/Grate** (Orifice Controls 0.21 cfs @ 1.61 fps)

Pond 8P: WQ


Hydrograph
Inflow
Outflow
Primary
Secondary
0.78 cfs
0.23 cfs
0.21 cfs
Inflow Area=88,675 sf
Peak Elev=102.05'
Storage=4,965 cf
Flow (cfs)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
Time (hours)
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
120

Summary for Subcatchment 15S: S P. Dev ROW Quantity

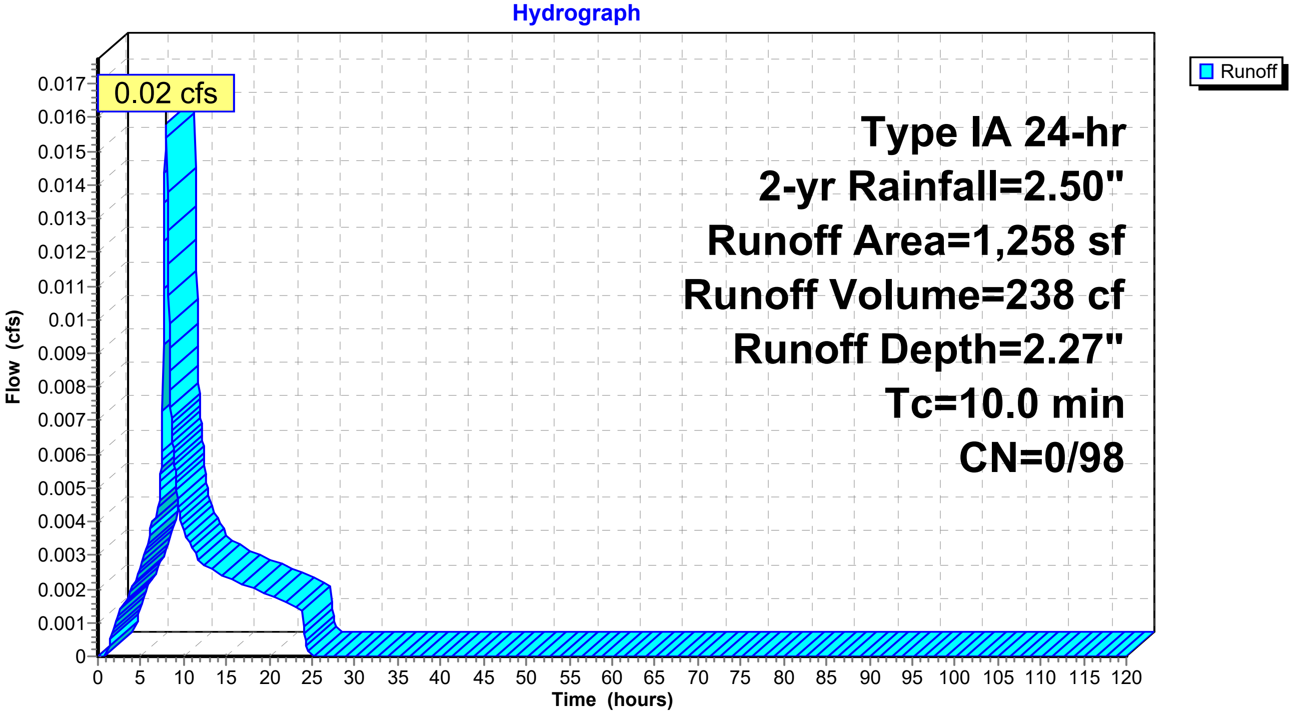
Runoff = 0.02 cfs @ 7.98 hrs, Volume= 238 cf, Depth= 2.27"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 2-yr Rainfall=2.50"

	Area (sf)	CN	Description
*	1,258	98	south sw
	1,258	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 15S: S P. Dev ROW Quantity



SOUTH TOTAL SITE DISCHARGE- 2-YEAR STORM

Summary for Pond 17P: (new Pond)

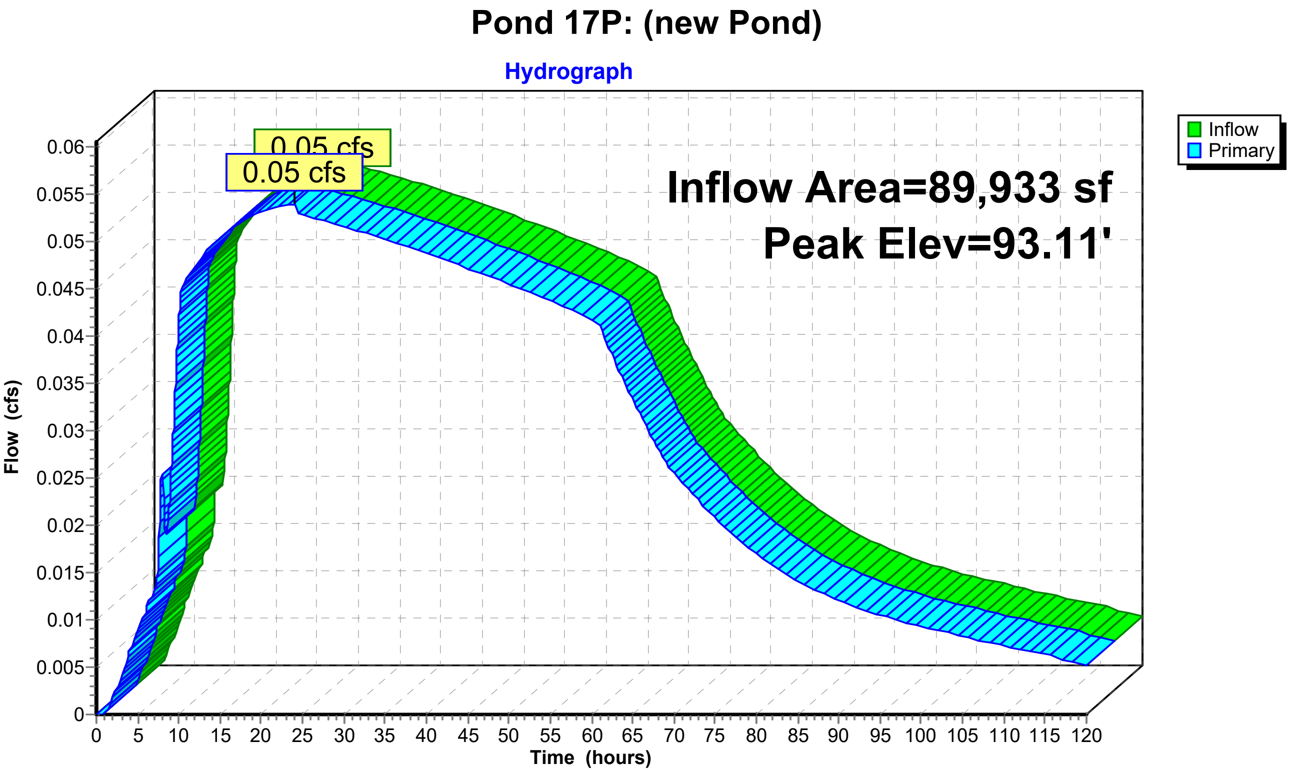
[57] Hint: Peaked at 93.11' (Flood elevation advised)

Inflow Area = 89,933 sf, 69.63% Impervious, Inflow Depth > 1.68" for 2-yr event
Inflow = 0.05 cfs @ 24.00 hrs, Volume= 12,557 cf
Outflow = 0.05 cfs @ 24.00 hrs, Volume= 12,557 cf, Atten= 0%, Lag= 0.0 min
Primary = 0.05 cfs @ 24.00 hrs, Volume= 12,557 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.11' @ 24.00 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.05 cfs @ 24.00 hrs HW=93.11' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.05 cfs @ 1.13 fps)



SOUTH BASIN 5-YEAR STORM

SOUTH PRE-DEVELOPED 5-YEAR STORM

Summary for Subcatchment 3S: Pre South

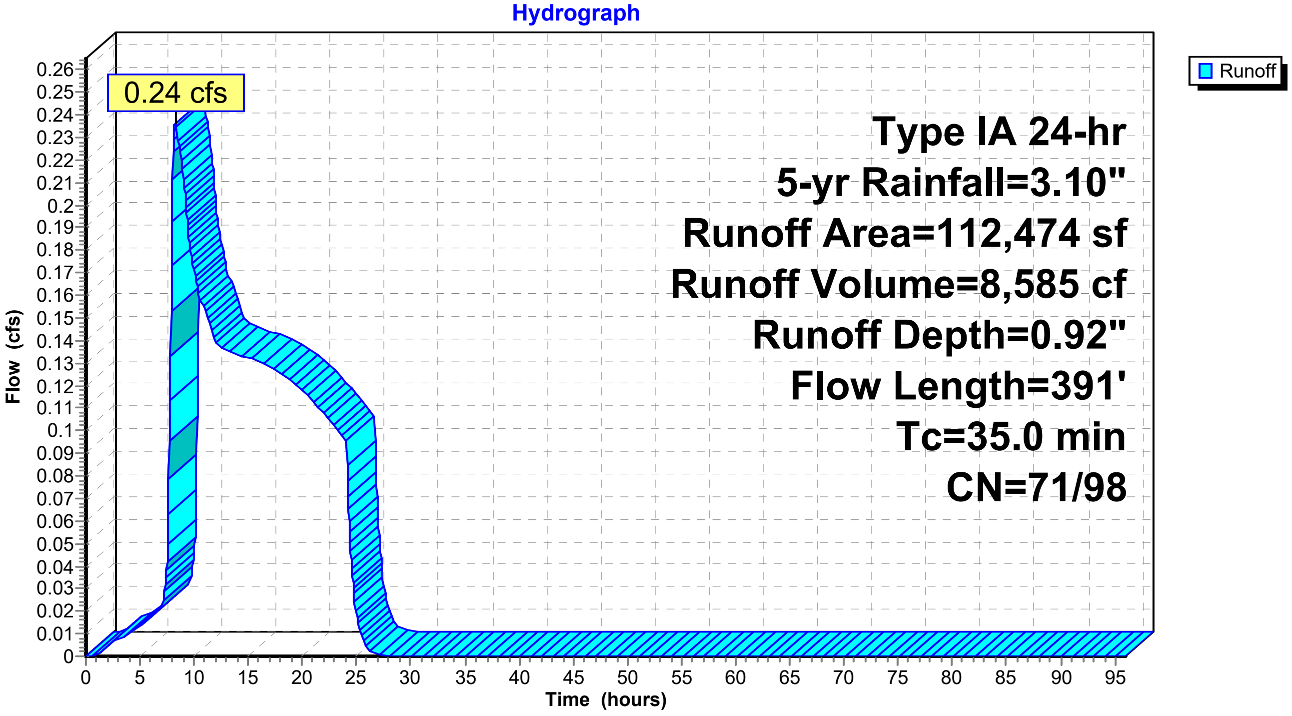
Runoff = 0.24 cfs @ 8.27 hrs, Volume= 8,585 cf, Depth= 0.92"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 5-yr Rainfall=3.10"

Area (sf)	CN	Description
10,143	85	Gravel roads, HSG B
622	98	Paved parking, HSG B
4,723	98	Roofs, HSG B
95,727	69	Pasture/grassland/range, Fair, HSG B
1,259	69	Pasture/grassland/range, Fair, HSG B
112,474	72	Weighted Average
107,129	71	95.25% Pervious Area
5,345	98	4.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.6	300	0.0267	0.14		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.4	91	0.0570	3.58		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
35.0	391	Total			

Subcatchment 3S: Pre South



SOUTH POST-DEVELOPED BASIN RUNOFF - 5-YEAR STORM

Summary for Subcatchment 9S: S Post-developed HUD

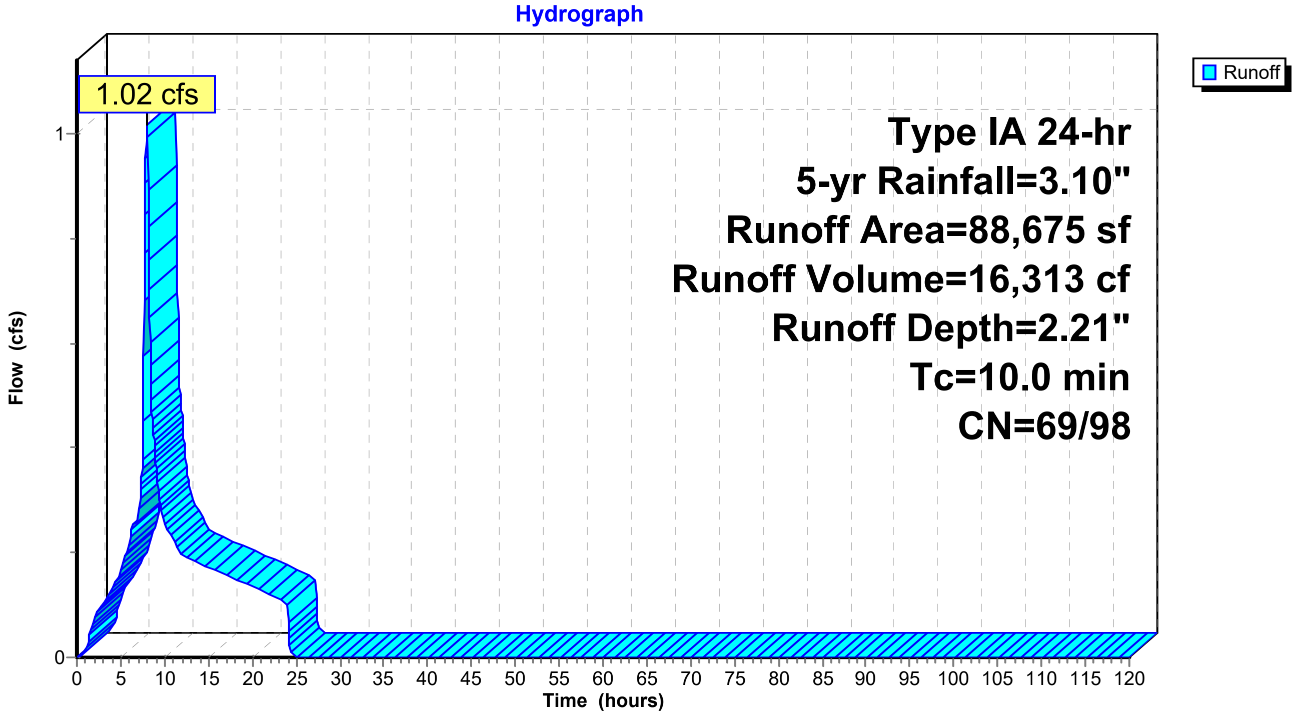
Runoff = 1.02 cfs @ 7.98 hrs, Volume= 16,313 cf, Depth= 2.21"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 5-yr Rainfall=3.10"

	Area (sf)	CN	Description
*	61,366	98	
	27,309	69	50-75% Grass cover, Fair, HSG B
	88,675	89	Weighted Average
	27,309	69	30.80% Pervious Area
	61,366	98	69.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 9S: S Post-developed HUD



Summary for Pond 6P: Detention

Inflow Area = 88,675 sf, 69.20% Impervious, Inflow Depth > 2.18" for 5-yr event
Inflow = 0.50 cfs @ 8.49 hrs, Volume= 16,087 cf
Outflow = 0.17 cfs @ 15.50 hrs, Volume= 16,059 cf, Atten= 66%, Lag= 420.9 min
Primary = 0.05 cfs @ 15.50 hrs, Volume= 12,701 cf
Secondary = 0.12 cfs @ 15.50 hrs, Volume= 3,358 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 97.59' @ 15.50 hrs Surf.Area= 3,221 sf Storage= 5,346 cf

Plug-Flow detention time= 775.7 min calculated for 16,052 cf (100% of inflow)
Center-of-Mass det. time= 765.9 min (2,405.0 - 1,639.1)

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	10,759 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

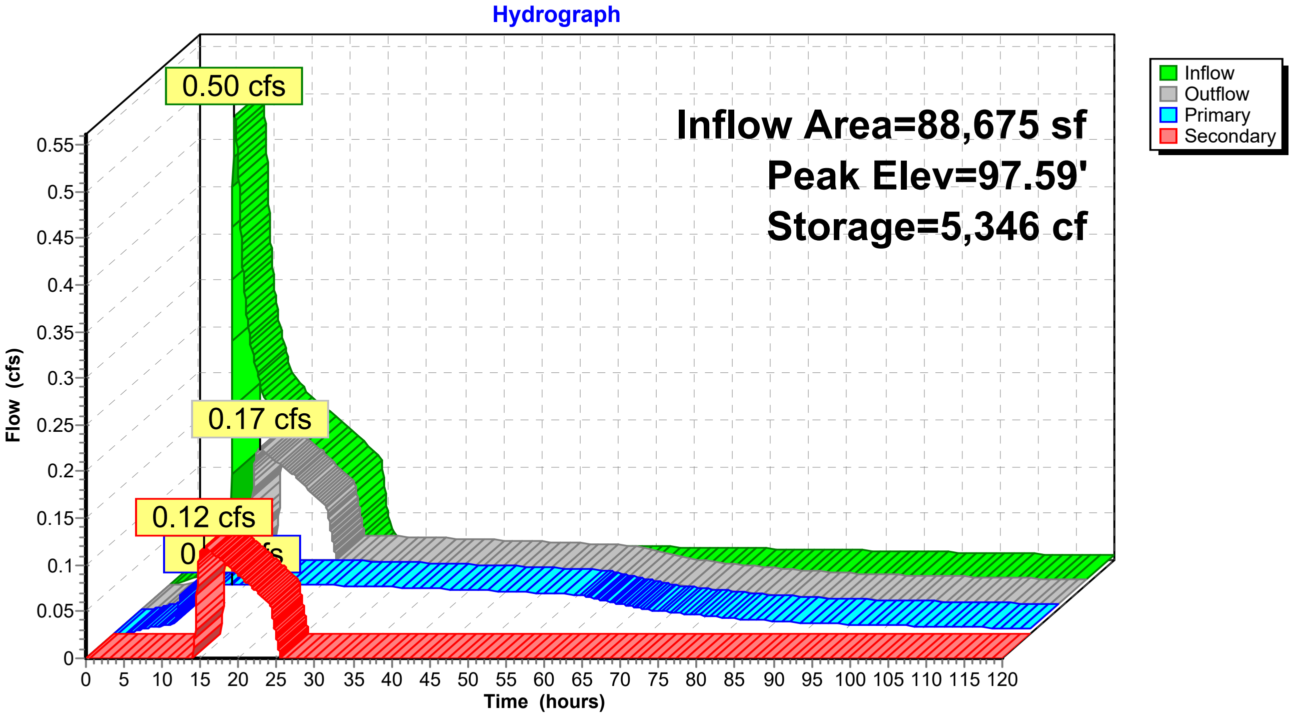
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
93.50	2,016	0.0	0	0	2,016
94.50	2,016	30.0	605	605	2,196
96.00	2,016	20.0	605	1,210	2,465
99.00	4,516	100.0	9,549	10,759	5,054

Device	Routing	Invert	Outlet Devices
#1	Primary	93.50'	**1.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	97.54'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.05 cfs @ 15.50 hrs HW=97.59' (Free Discharge)
⮤**1=Orifice/Grate** (Orifice Controls 0.05 cfs @ 9.74 fps)

Secondary OutFlow Max=0.11 cfs @ 15.50 hrs HW=97.59' (Free Discharge)
⮤**2=Orifice/Grate** (Weir Controls 0.11 cfs @ 0.76 fps)

Pond 6P: Detention



Summary for Pond 8P: WQ

Inflow Area = 88,675 sf, 69.20% Impervious, Inflow Depth = 2.21" for 5-yr event
Inflow = 1.02 cfs @ 7.98 hrs, Volume= 16,313 cf
Outflow = 0.50 cfs @ 8.49 hrs, Volume= 16,087 cf, Atten= 51%, Lag= 30.3 min
Primary = 0.02 cfs @ 8.49 hrs, Volume= 5,659 cf
Secondary = 0.48 cfs @ 8.49 hrs, Volume= 10,428 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 102.18' @ 8.49 hrs Surf.Area= 3,235 sf Storage= 5,356 cf

Plug-Flow detention time= 952.9 min calculated for 16,087 cf (99% of inflow)
Center-of-Mass det. time= 942.5 min (1,639.1 - 696.6)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	8,299 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

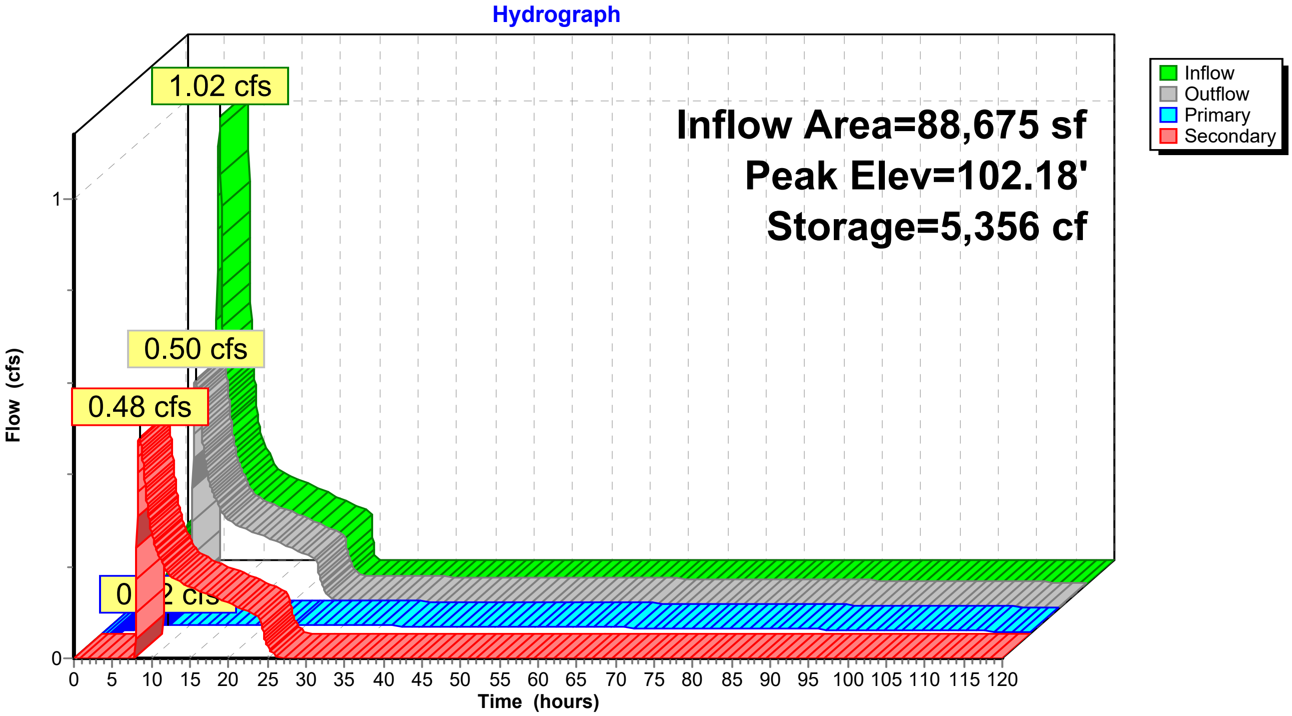
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	1,763	0.0	0	0	1,763
103.00	3,910	100.0	8,299	8,299	4,000

Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.72" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.83'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.02 cfs @ 8.49 hrs HW=102.17' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 7.10 fps)

Secondary OutFlow Max=0.48 cfs @ 8.49 hrs HW=102.17' (Free Discharge)
└─**2=Orifice/Grate** (Orifice Controls 0.48 cfs @ 2.00 fps)

Pond 8P: WQ


Hydrograph
1.02 cfs
0.50 cfs
0.48 cfs
0
2 cfs
Inflow Area=88,675 sf
Peak Elev=102.18'
Storage=5,356 cf
🟩 Inflow
⬜ Outflow
🟦 Primary
🟥 Secondary
Flow (cfs)
1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
Time (hours)

Summary for Subcatchment 15S: S P. Dev ROW Quantity

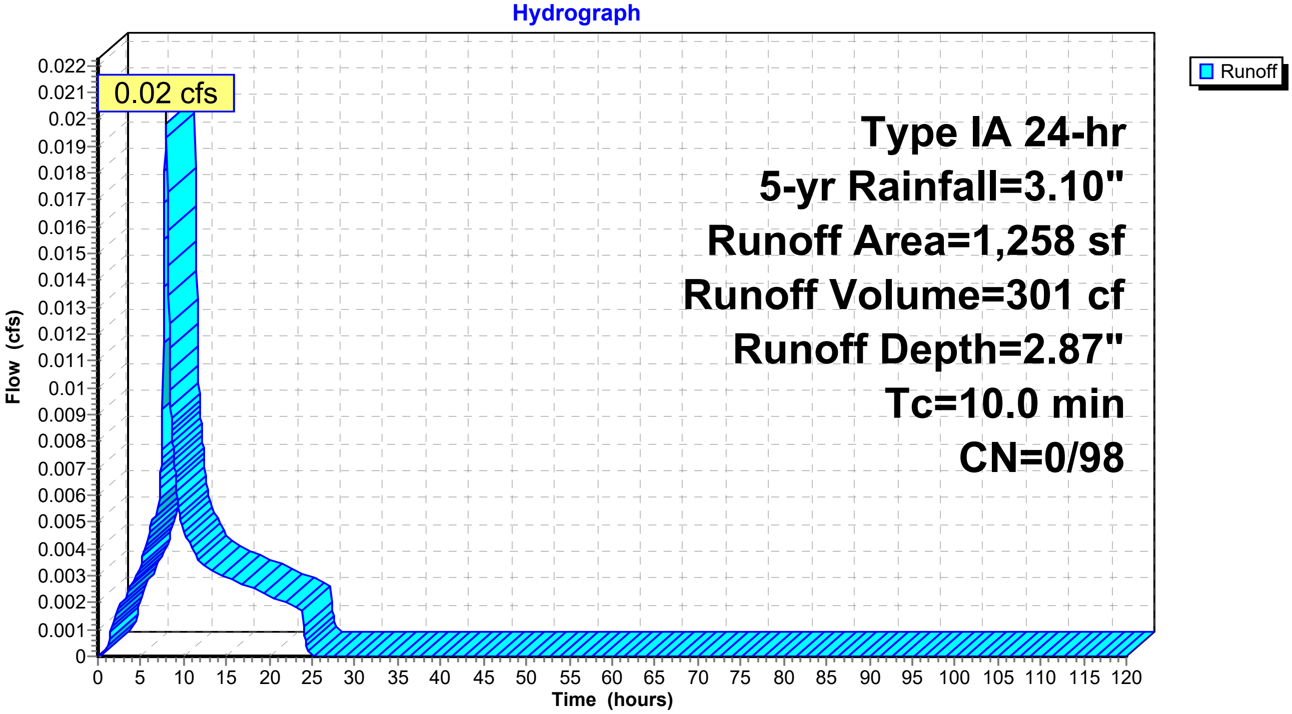
Runoff = 0.02 cfs @ 7.98 hrs, Volume= 301 cf, Depth= 2.87"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 5-yr Rainfall=3.10"

	Area (sf)	CN	Description
*	1,258	98	south sw
	1,258	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 15S: S P. Dev ROW Quantity



SOUTH TOTAL DISCHARGE FROM SITE - 5-YEAR STORM

Summary for Pond 17P: (new Pond)

[57] Hint: Peaked at 93.20' (Flood elevation advised)

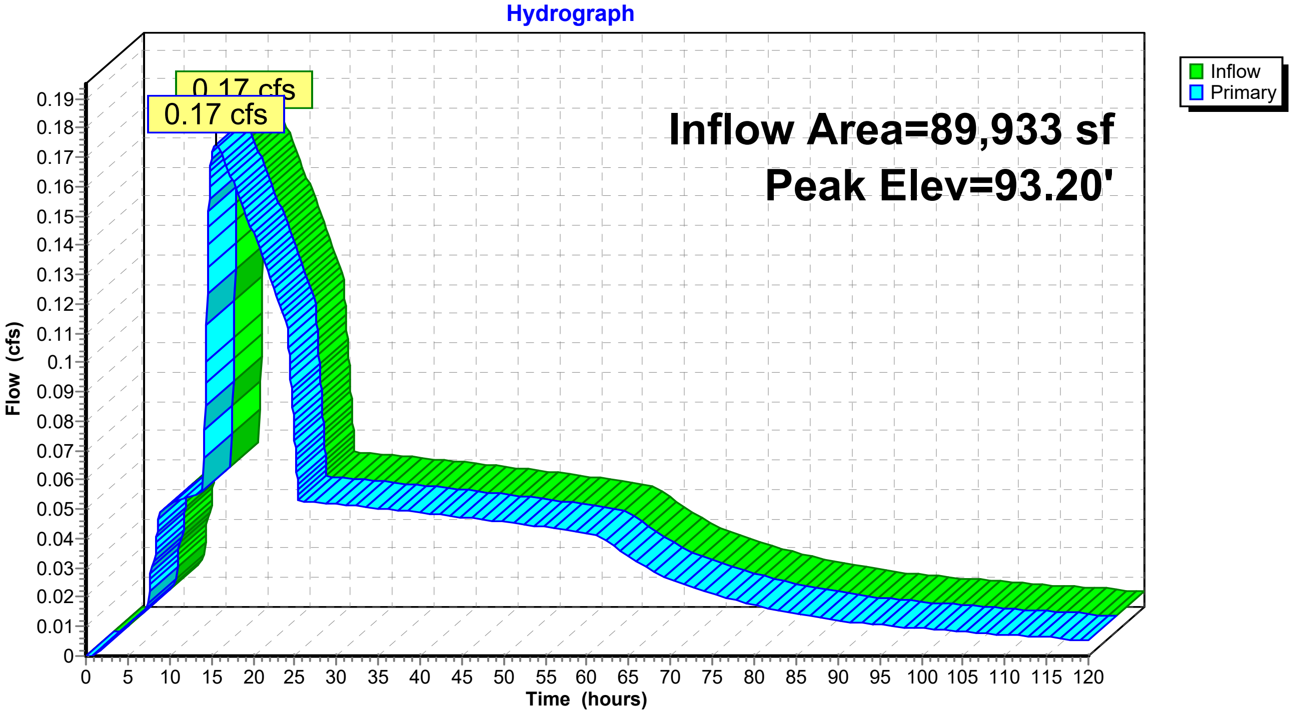
Inflow Area = 89,933 sf, 69.63% Impervious, Inflow Depth > 2.18" for 5-yr event
Inflow = 0.17 cfs @ 15.50 hrs, Volume= 16,360 cf
Outflow = 0.17 cfs @ 15.50 hrs, Volume= 16,360 cf, Atten= 0%, Lag= 0.0 min
Primary = 0.17 cfs @ 15.50 hrs, Volume= 16,360 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.20' @ 15.50 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.17 cfs @ 15.50 hrs HW=93.20' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.17 cfs @ 1.53 fps)

Pond 17P: (new Pond)



SOUTH BASIN 10-YEAR STORM

Summary for Subcatchment 3S: Pre South

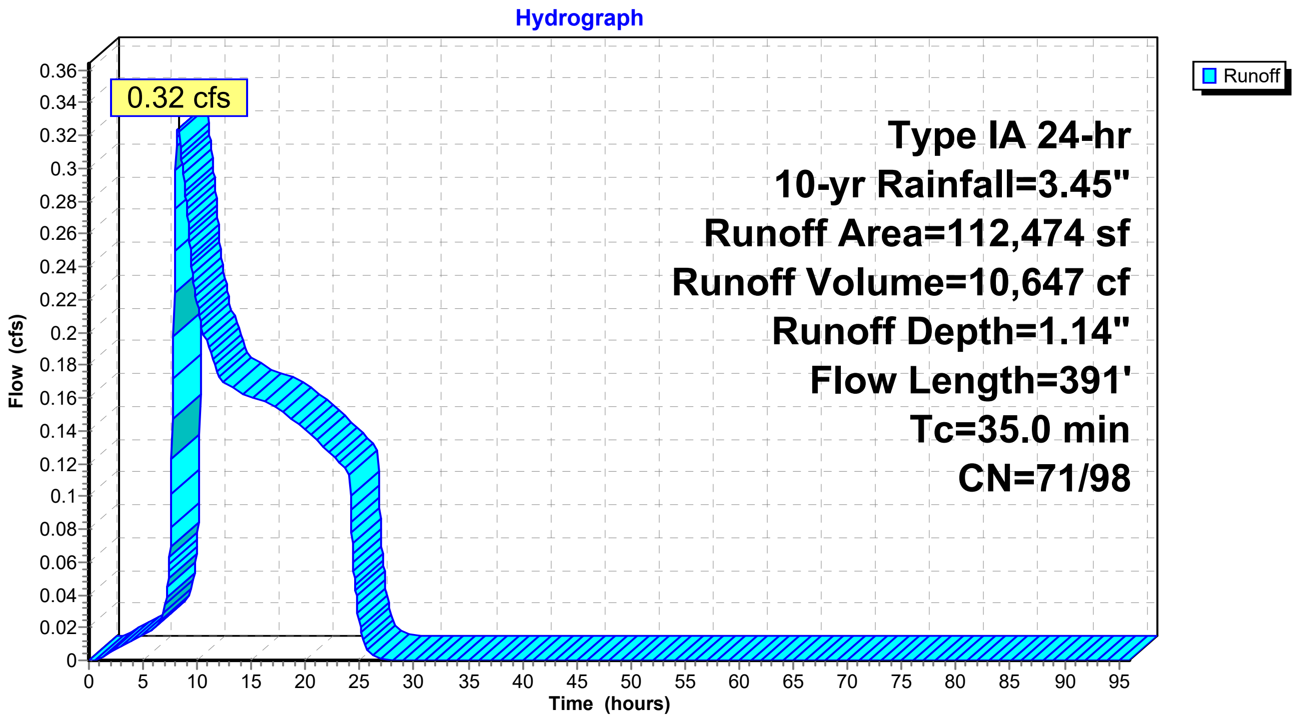
Runoff = 0.32 cfs @ 8.23 hrs, Volume= 10,647 cf, Depth= 1.14"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10-yr Rainfall=3.45"

Area (sf)	CN	Description
10,143	85	Gravel roads, HSG B
622	98	Paved parking, HSG B
4,723	98	Roofs, HSG B
95,727	69	Pasture/grassland/range, Fair, HSG B
1,259	69	Pasture/grassland/range, Fair, HSG B
112,474	72	Weighted Average
107,129	71	95.25% Pervious Area
5,345	98	4.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.6	300	0.0267	0.14		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.4	91	0.0570	3.58		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
35.0	391	Total			

Subcatchment 3S: Pre South



Summary for Subcatchment 9S: S Post-developed HUD

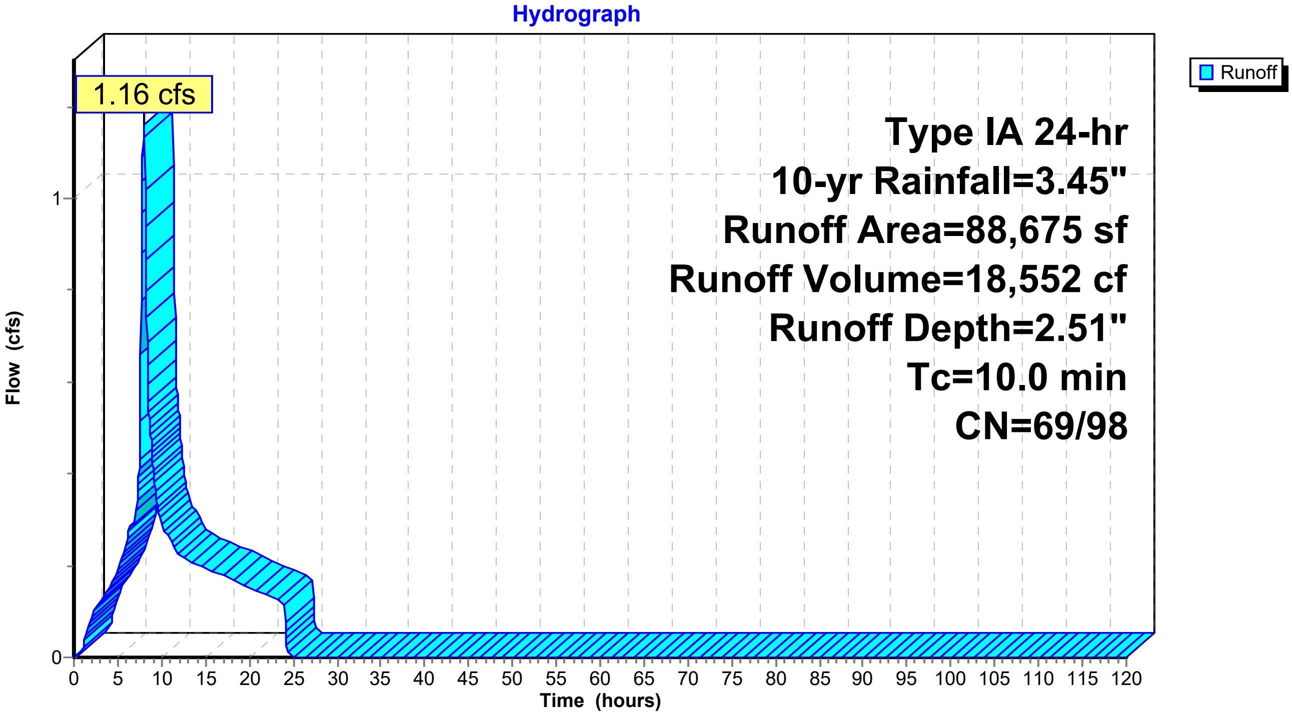
Runoff = 1.16 cfs @ 7.98 hrs, Volume= 18,552 cf, Depth= 2.51"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10-yr Rainfall=3.45"

	Area (sf)	CN	Description
*	61,366	98	
	27,309	69	50-75% Grass cover, Fair, HSG B
	88,675	89	Weighted Average
	27,309	69	30.80% Pervious Area
	61,366	98	69.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 9S: S Post-developed HUD



Summary for Pond 6P: Detention

Inflow Area = 88,675 sf, 69.20% Impervious, Inflow Depth > 2.48" for 10-yr event
Inflow = 0.73 cfs @ 8.31 hrs, Volume= 18,324 cf
Outflow = 0.22 cfs @ 12.93 hrs, Volume= 18,297 cf, Atten= 70%, Lag= 276.6 min
Primary = 0.05 cfs @ 12.93 hrs, Volume= 12,801 cf
Secondary = 0.17 cfs @ 12.93 hrs, Volume= 5,495 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 97.61' @ 12.93 hrs Surf.Area= 3,234 sf Storage= 5,396 cf

Plug-Flow detention time= 701.2 min calculated for 18,289 cf (100% of inflow)
Center-of-Mass det. time= 692.5 min (2,223.6 - 1,531.2)

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	10,759 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

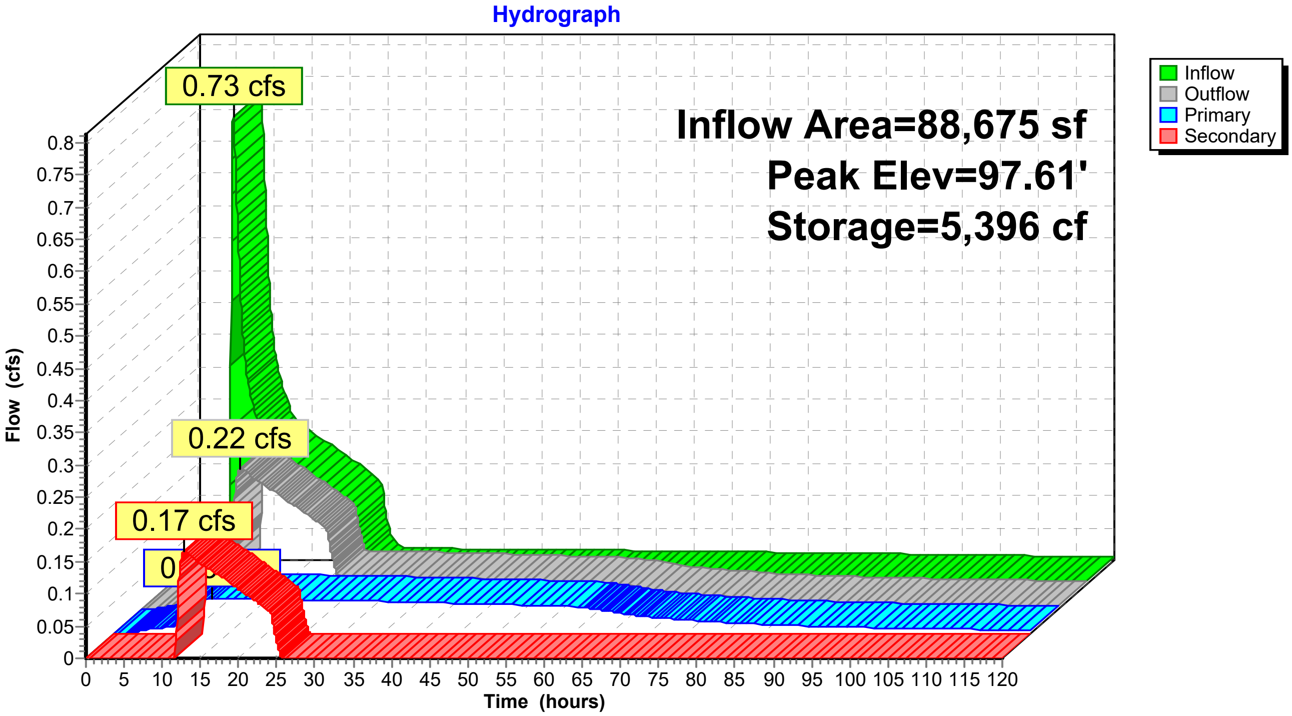
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
93.50	2,016	0.0	0	0	2,016
94.50	2,016	30.0	605	605	2,196
96.00	2,016	20.0	605	1,210	2,465
99.00	4,516	100.0	9,549	10,759	5,054

Device	Routing	Invert	Outlet Devices
#1	Primary	93.50'	**1.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	97.54'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.05 cfs @ 12.93 hrs HW=97.61' (Free Discharge)
↰**1=Orifice/Grate** (Orifice Controls 0.05 cfs @ 9.76 fps)

Secondary OutFlow Max=0.16 cfs @ 12.93 hrs HW=97.61' (Free Discharge)
↰**2=Orifice/Grate** (Weir Controls 0.16 cfs @ 0.86 fps)

Pond 6P: Detention



Summary for Pond 8P: WQ

```
Inflow Area =        88,675 sf,  69.20% Impervious,  Inflow Depth =   2.51"    for  10-yr event
Inflow      =      1.16 cfs @    7.98 hrs,  Volume=          18,552 cf
Outflow     =      0.73 cfs @    8.31 hrs,  Volume=          18,324 cf,  Atten= 37%,  Lag= 20.0 min
Primary     =      0.02 cfs @    8.31 hrs,  Volume=           5,687 cf
Secondary =        0.71 cfs @    8.31 hrs,  Volume=          12,637 cf
```

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 102.25' @ 8.31 hrs Surf.Area= 3,298 sf Storage= 5,616 cf

Plug-Flow detention time= 845.4 min calculated for 18,324 cf (99% of inflow)
Center-of-Mass det. time= 836.2 min (1,531.2 - 695.0)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	8,299 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

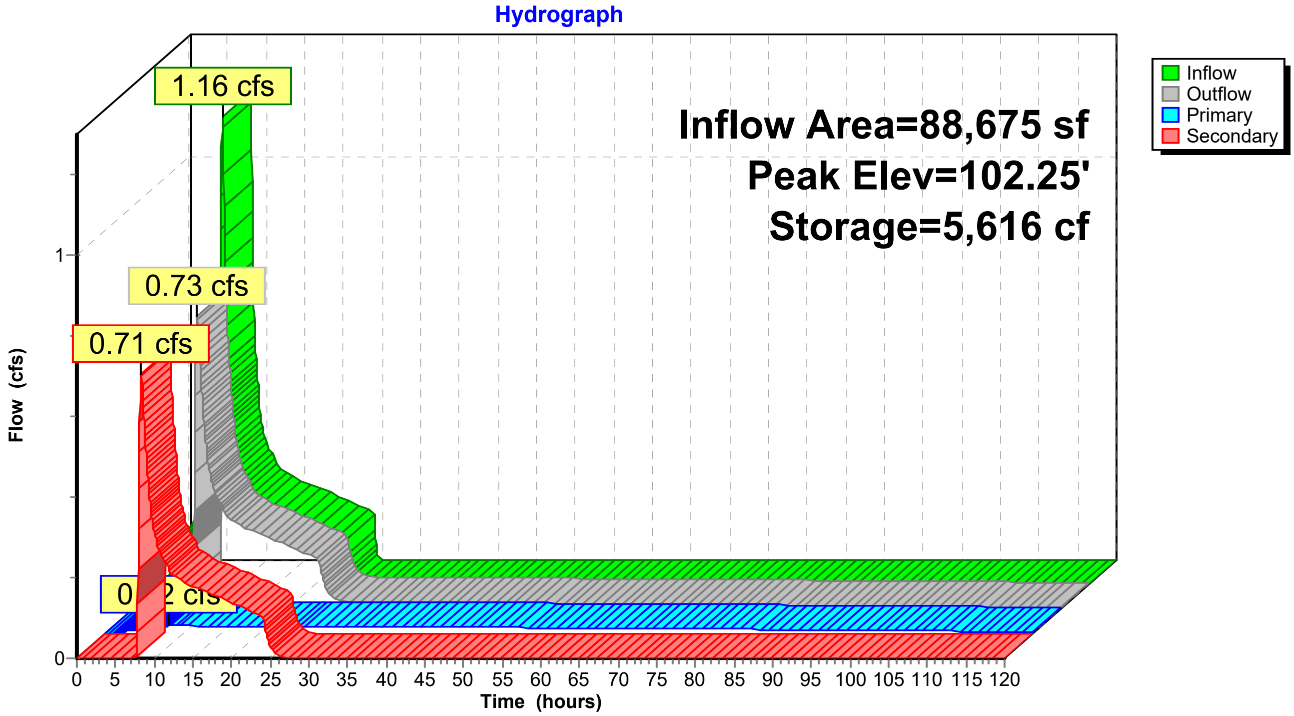
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	1,763	0.0	0	0	1,763
103.00	3,910	100.0	8,299	8,299	4,000

Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.72" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.83'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.02 cfs @ 8.31 hrs HW=102.25' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 7.23 fps)

Secondary OutFlow Max=0.70 cfs @ 8.31 hrs HW=102.25' (Free Discharge)
↑—**2=Orifice/Grate** (Orifice Controls 0.70 cfs @ 2.22 fps)

Pond 8P: WQ


Hydrograph
1.16 cfs
0.73 cfs
0.71 cfs
0 2 cfs
Inflow Area=88,675 sf
Peak Elev=102.25'
Storage=5,616 cf
Inflow
Outflow
Primary
Secondary
Flow (cfs)
1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120
Time (hours)

Summary for Subcatchment 15S: S P. Dev ROW Quantity

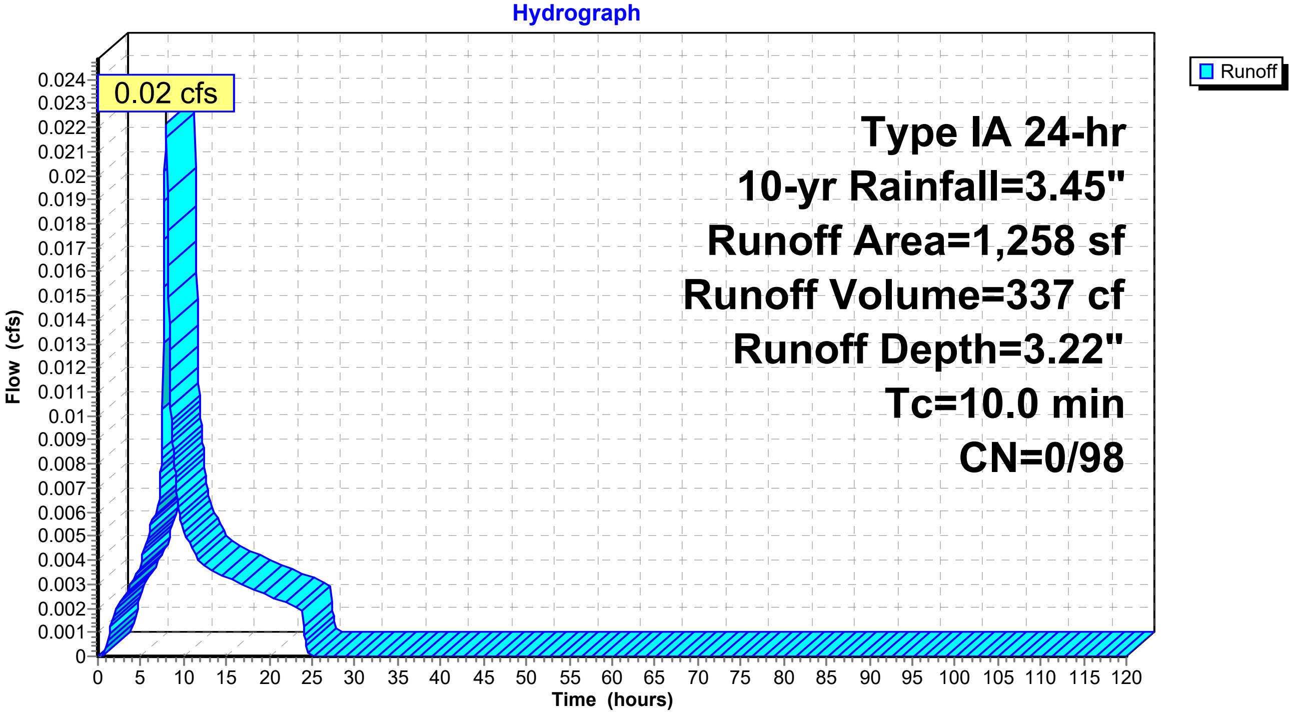
Runoff = 0.02 cfs @ 7.98 hrs, Volume= 337 cf, Depth= 3.22"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 10-yr Rainfall=3.45"

	Area (sf)	CN	Description
*	1,258	98	south sw
	1,258	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 15S: S P. Dev ROW Quantity



SOUTH TOTAL SITE DISCHARGE - 10-YEAR STORM

Summary for Pond 17P: (new Pond)

[57] Hint: Peaked at 93.23' (Flood elevation advised)

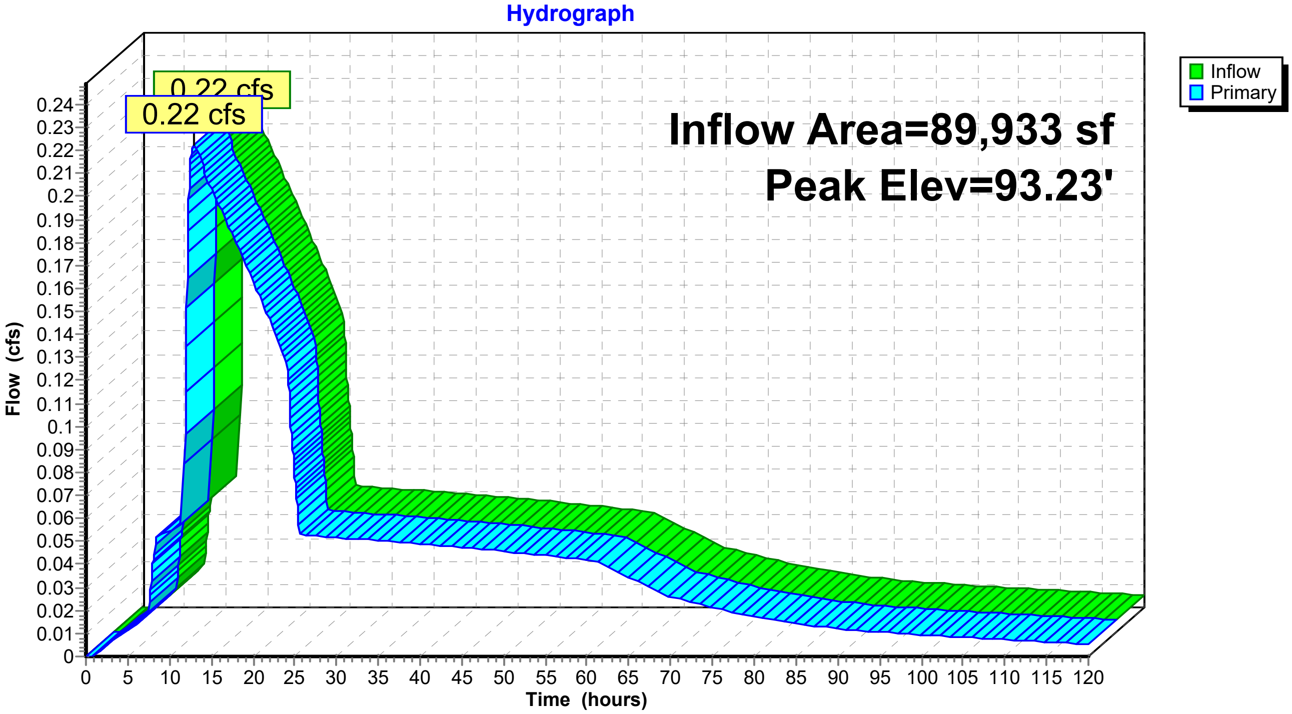
```
Inflow Area =        89,933 sf,  69.63% Impervious,  Inflow Depth >   2.49"    for  10-yr event
Inflow      =      0.22 cfs @   12.92 hrs,  Volume=          18,634 cf
Outflow     =      0.22 cfs @   12.92 hrs,  Volume=          18,634 cf,  Atten= 0%,  Lag= 0.0 min
Primary     =      0.22 cfs @   12.92 hrs,  Volume=          18,634 cf
```

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.23' @ 12.92 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.22 cfs @ 12.92 hrs HW=93.23' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.22 cfs @ 1.63 fps)

Pond 17P: (new Pond)



SOUTH BASIN 25-YEAR STORM

SOUTH PREDEVELOPED 25-YEAR STORM

Summary for Subcatchment 3S: Pre South

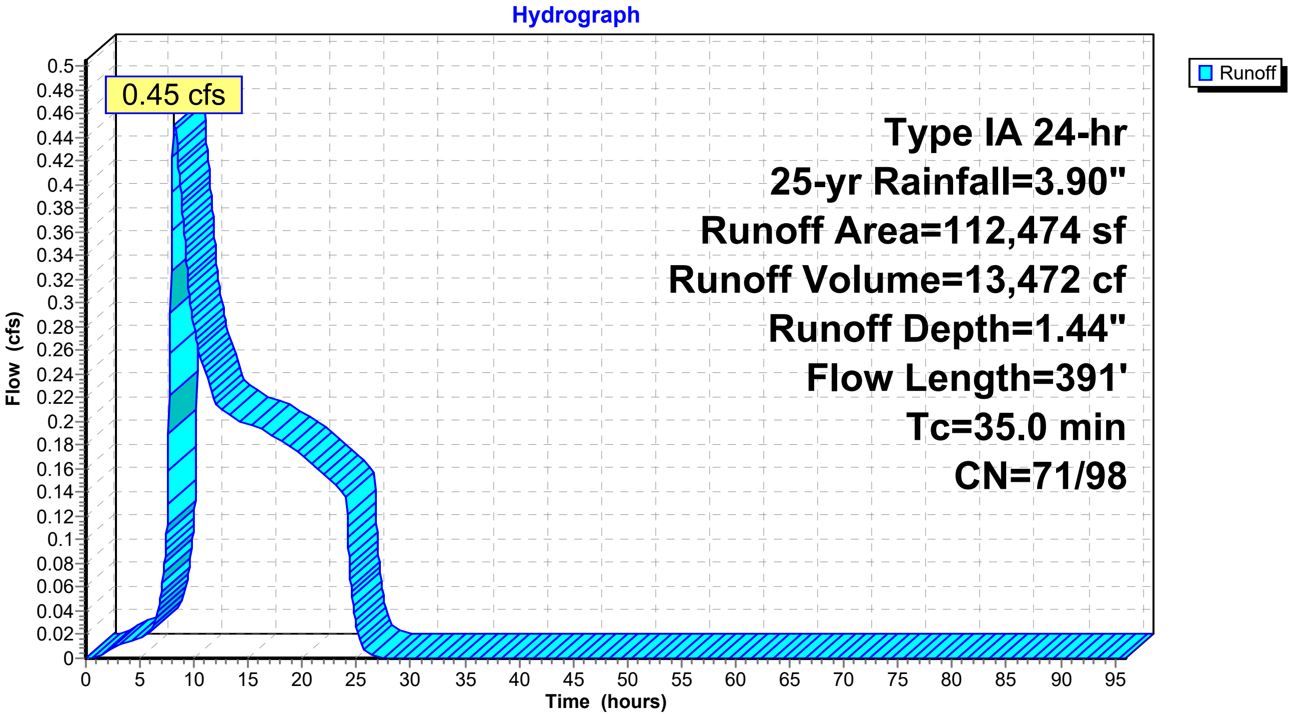
Runoff = 0.45 cfs @ 8.19 hrs, Volume= 13,472 cf, Depth= 1.44"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-yr Rainfall=3.90"

Area (sf)	CN	Description
10,143	85	Gravel roads, HSG B
622	98	Paved parking, HSG B
4,723	98	Roofs, HSG B
95,727	69	Pasture/grassland/range, Fair, HSG B
1,259	69	Pasture/grassland/range, Fair, HSG B
112,474	72	Weighted Average
107,129	71	95.25% Pervious Area
5,345	98	4.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
34.6	300	0.0267	0.14		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 2.50"
0.4	91	0.0570	3.58		**Shallow Concentrated Flow, shallow** Grassed Waterway Kv= 15.0 fps
35.0	391	Total			

Subcatchment 3S: Pre South



SOUTH POST-DEVELOPED BASIN RUNOFF - 25-YEAR STORM

Summary for Subcatchment 9S: S Post-developed HUD

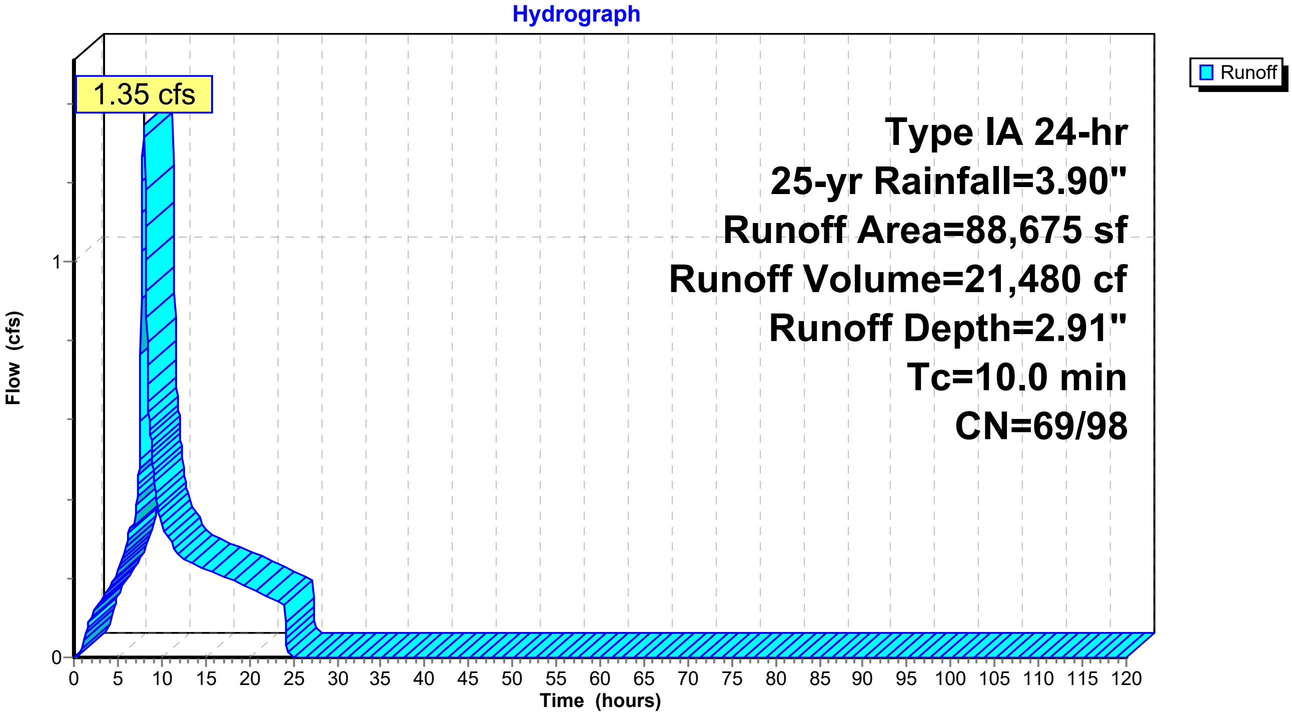
Runoff = 1.35 cfs @ 7.98 hrs, Volume= 21,480 cf, Depth= 2.91"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-yr Rainfall=3.90"

	Area (sf)	CN	Description
*	61,366	98	
	27,309	69	50-75% Grass cover, Fair, HSG B
	88,675	89	Weighted Average
	27,309	69	30.80% Pervious Area
	61,366	98	69.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 9S: S Post-developed HUD



Summary for Pond 6P: Detention

Inflow Area = 88,675 sf, 69.20% Impervious, Inflow Depth > 2.88" for 25-yr event
Inflow = 1.00 cfs @ 8.20 hrs, Volume= 21,250 cf
Outflow = 0.32 cfs @ 10.94 hrs, Volume= 21,222 cf, Atten= 68%, Lag= 164.0 min
Primary = 0.05 cfs @ 10.94 hrs, Volume= 12,889 cf
Secondary = 0.27 cfs @ 10.94 hrs, Volume= 8,334 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 97.64' @ 10.94 hrs Surf.Area= 3,257 sf Storage= 5,486 cf

Plug-Flow detention time= 618.2 min calculated for 21,222 cf (100% of inflow)
Center-of-Mass det. time= 610.7 min (2,034.0 - 1,423.3)

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	10,759 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

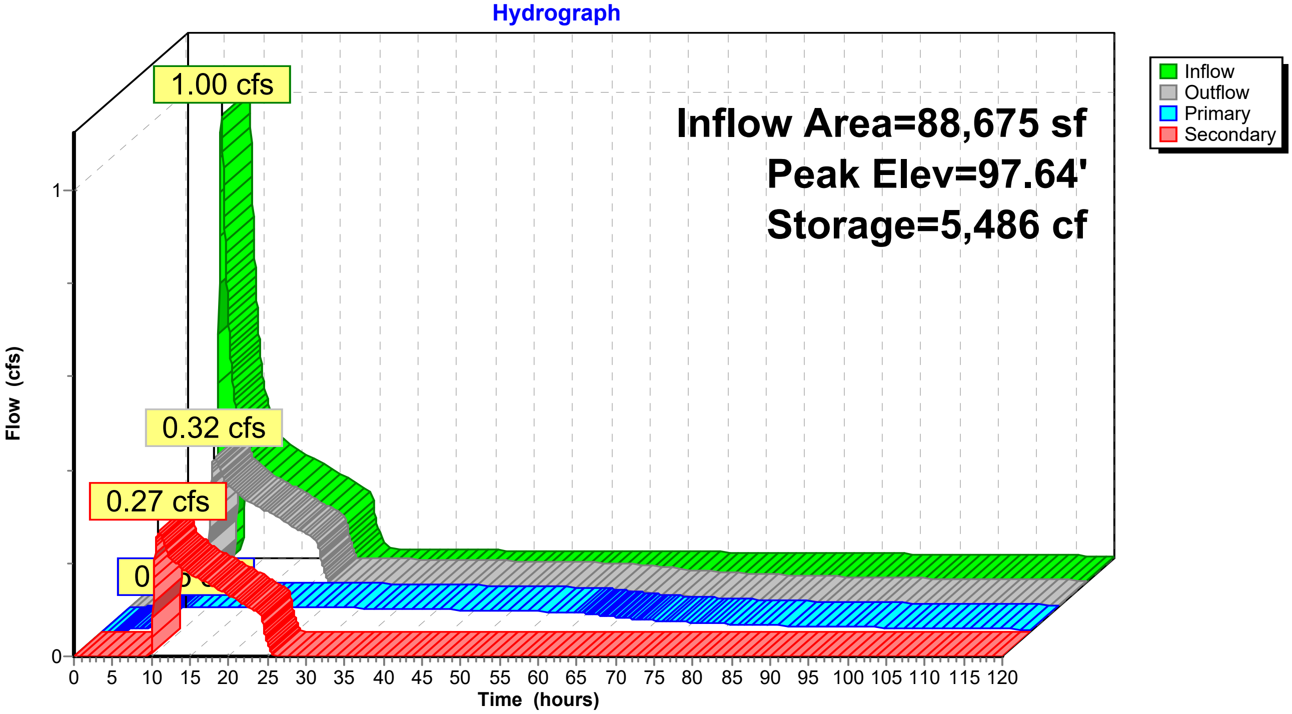
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
93.50	2,016	0.0	0	0	2,016
94.50	2,016	30.0	605	605	2,196
96.00	2,016	20.0	605	1,210	2,465
99.00	4,516	100.0	9,549	10,759	5,054

Device	Routing	Invert	Outlet Devices
#1	Primary	93.50'	**1.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	97.54'	**10.00" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.05 cfs @ 10.94 hrs HW=97.64' (Free Discharge)
↰**1=Orifice/Grate** (Orifice Controls 0.05 cfs @ 9.79 fps)

Secondary OutFlow Max=0.26 cfs @ 10.94 hrs HW=97.64' (Free Discharge)
↰**2=Orifice/Grate** (Weir Controls 0.26 cfs @ 1.02 fps)

Pond 6P: Detention



Summary for Pond 8P: WQ

```
Inflow Area =        88,675 sf,  69.20% Impervious,  Inflow Depth =   2.91"    for  25-yr event
Inflow      =      1.35 cfs @    7.98 hrs,  Volume=          21,480 cf
Outflow     =      1.00 cfs @    8.20 hrs,  Volume=          21,250 cf,  Atten= 26%,  Lag= 13.3 min
Primary     =      0.02 cfs @    8.20 hrs,  Volume=           5,719 cf
Secondary =        0.98 cfs @    8.20 hrs,  Volume=          15,531 cf
```

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 102.34' @ 8.20 hrs Surf.Area= 3,366 sf Storage= 5,904 cf

Plug-Flow detention time= 736.2 min calculated for 21,241 cf (99% of inflow)
Center-of-Mass det. time= 730.3 min (1,423.3 - 693.1)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	8,299 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

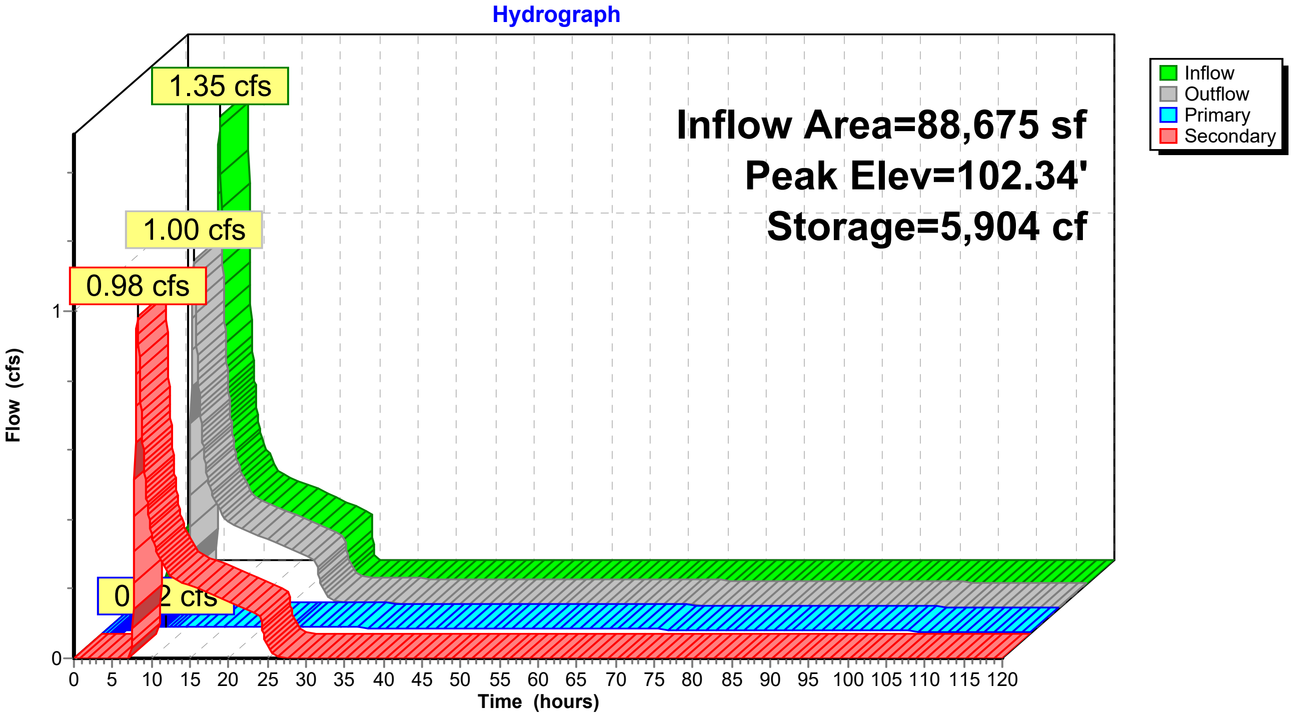
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	1,763	0.0	0	0	1,763
103.00	3,910	100.0	8,299	8,299	4,000

Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.72" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.83'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.02 cfs @ 8.20 hrs HW=102.34' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 7.37 fps)

Secondary OutFlow Max=0.98 cfs @ 8.20 hrs HW=102.34' (Free Discharge)
↑—**2=Orifice/Grate** (Orifice Controls 0.98 cfs @ 2.43 fps)

Pond 8P: WQ


Hydrograph
1.35 cfs
1.00 cfs
0.98 cfs
0.02 cfs
Inflow Area=88,675 sf
Peak Elev=102.34'
Storage=5,904 cf
Inflow
Outflow
Primary
Secondary
Flow (cfs)
0
1
Time (hours)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

Summary for Subcatchment 15S: S P. Dev ROW Quantity

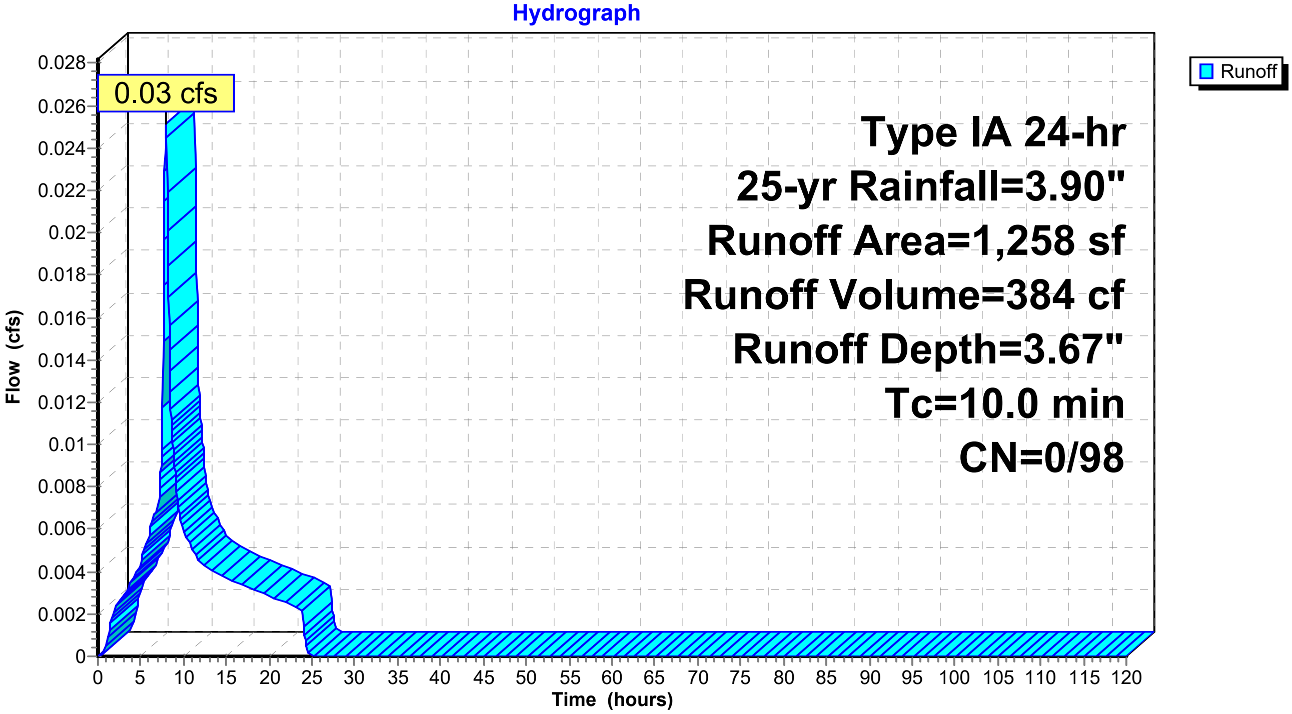
Runoff = 0.03 cfs @ 7.98 hrs, Volume= 384 cf, Depth= 3.67"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-yr Rainfall=3.90"

	Area (sf)	CN	Description
*	1,258	98	south sw
	1,258	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 15S: S P. Dev ROW Quantity



Summary for Pond 17P: (new Pond)

[57] Hint: Peaked at 93.28' (Flood elevation advised)

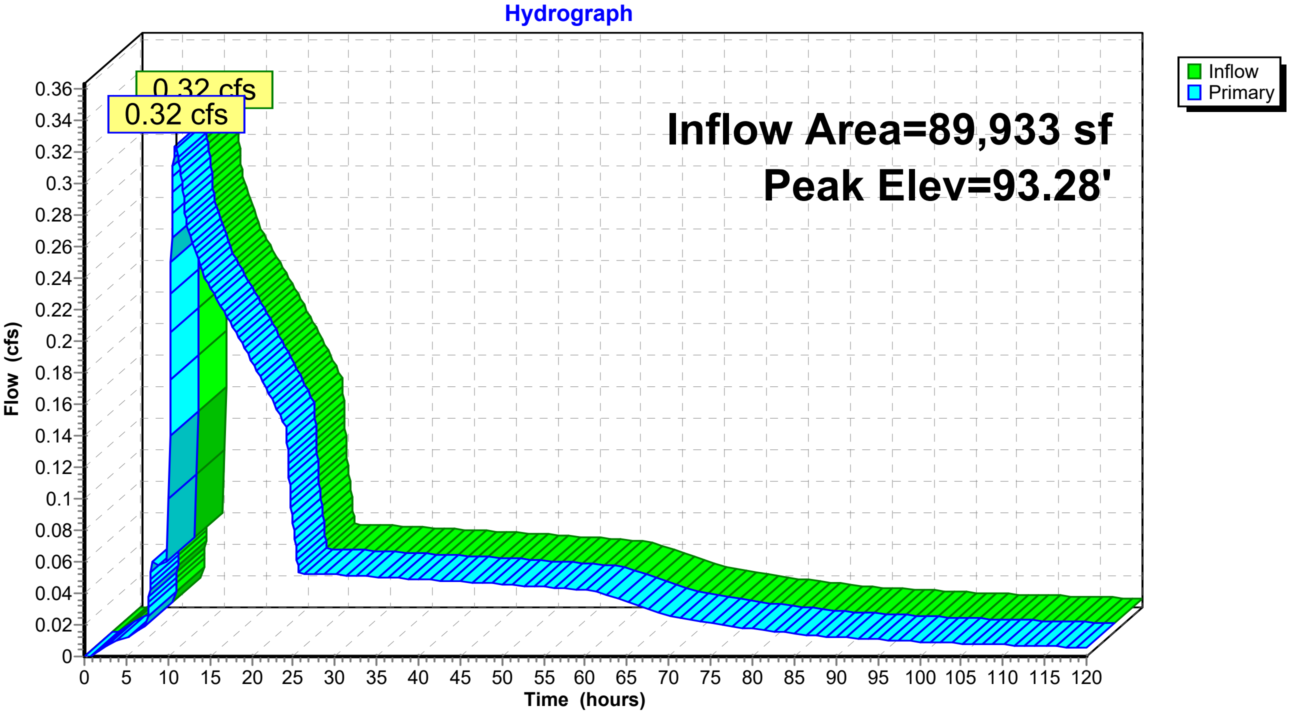
```
Inflow Area =       89,933 sf,  69.63% Impervious,  Inflow Depth >  2.88"   for  25-yr event
Inflow      =     0.32 cfs @  10.93 hrs,  Volume=         21,606 cf
Outflow     =     0.32 cfs @  10.93 hrs,  Volume=         21,606 cf,  Atten= 0%,  Lag= 0.0 min
Primary     =     0.32 cfs @  10.93 hrs,  Volume=         21,606 cf
```

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.28' @ 10.93 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.32 cfs @ 10.93 hrs HW=93.28' (Free Discharge)
↑—**1=Orifice/Grate** (Orifice Controls 0.32 cfs @ 1.80 fps)

Pond 17P: (new Pond)



SOUTH BASIN WQ-HUD STORM

SOUTH POST-DEVELOPED BASIN RUNOFF - WQ-HUD STORM

Summary for Subcatchment 9S: S Post-developed HUD

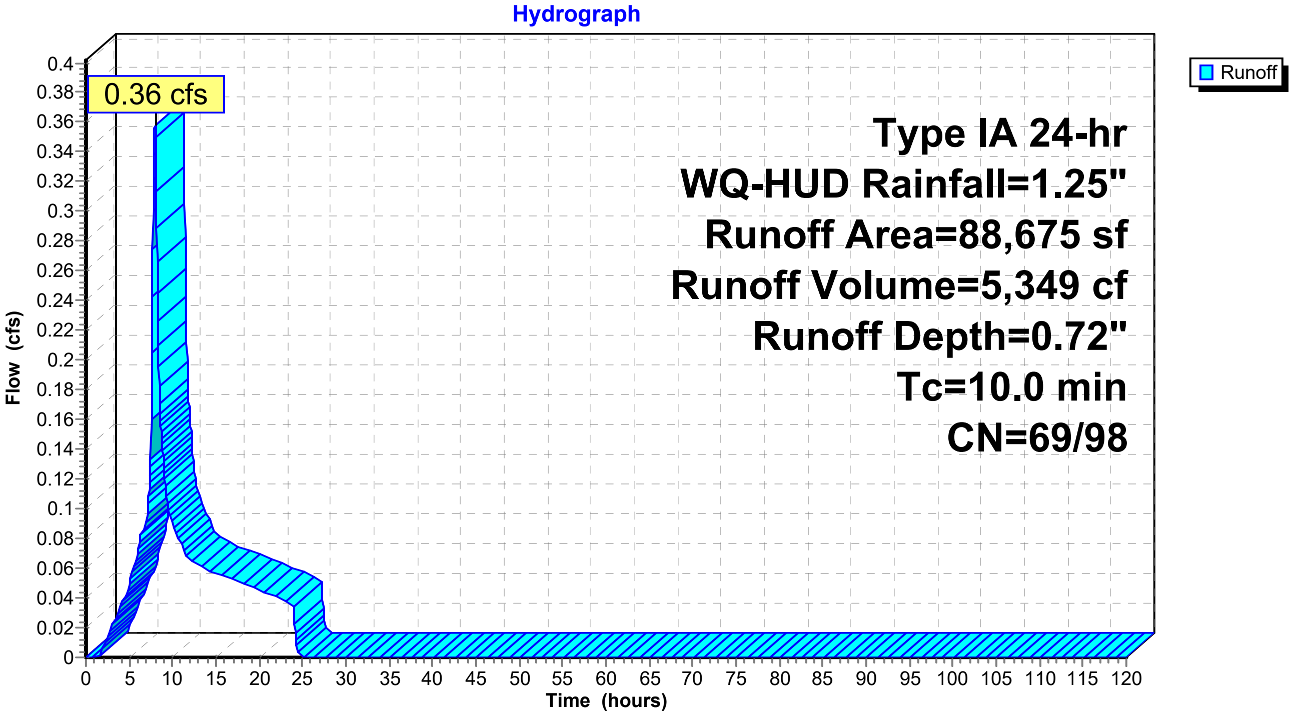
Runoff = 0.36 cfs @ 7.98 hrs, Volume= 5,349 cf, Depth= 0.72"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Type IA 24-hr WQ-HUD Rainfall=1.25"

	Area (sf)	CN	Description
*	61,366	98	
	27,309	69	50-75% Grass cover, Fair, HSG B
	88,675	89	Weighted Average
	27,309	69	30.80% Pervious Area
	61,366	98	69.20% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 9S: S Post-developed HUD



Summary for Pond 8P: WQ

Inflow Area = 88,675 sf, 69.20% Impervious, Inflow Depth = 0.72" for WQ-HUD event
Inflow = 0.36 cfs @ 7.98 hrs, Volume= 5,349 cf
Outflow = 0.02 cfs @ 24.14 hrs, Volume= 5,179 cf, Atten= 95%, Lag= 969.4 min
Primary = 0.02 cfs @ 24.14 hrs, Volume= 5,179 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 101.82' @ 24.14 hrs Surf.Area= 2,966 sf Storage= 4,261 cf

Plug-Flow detention time= 2,472.0 min calculated for 5,177 cf (97% of inflow)
Center-of-Mass det. time= 2,450.5 min (3,162.9 - 712.4)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	8,299 cf	**Custom Stage Data (Pyramidal)**Listed below (Recalc)

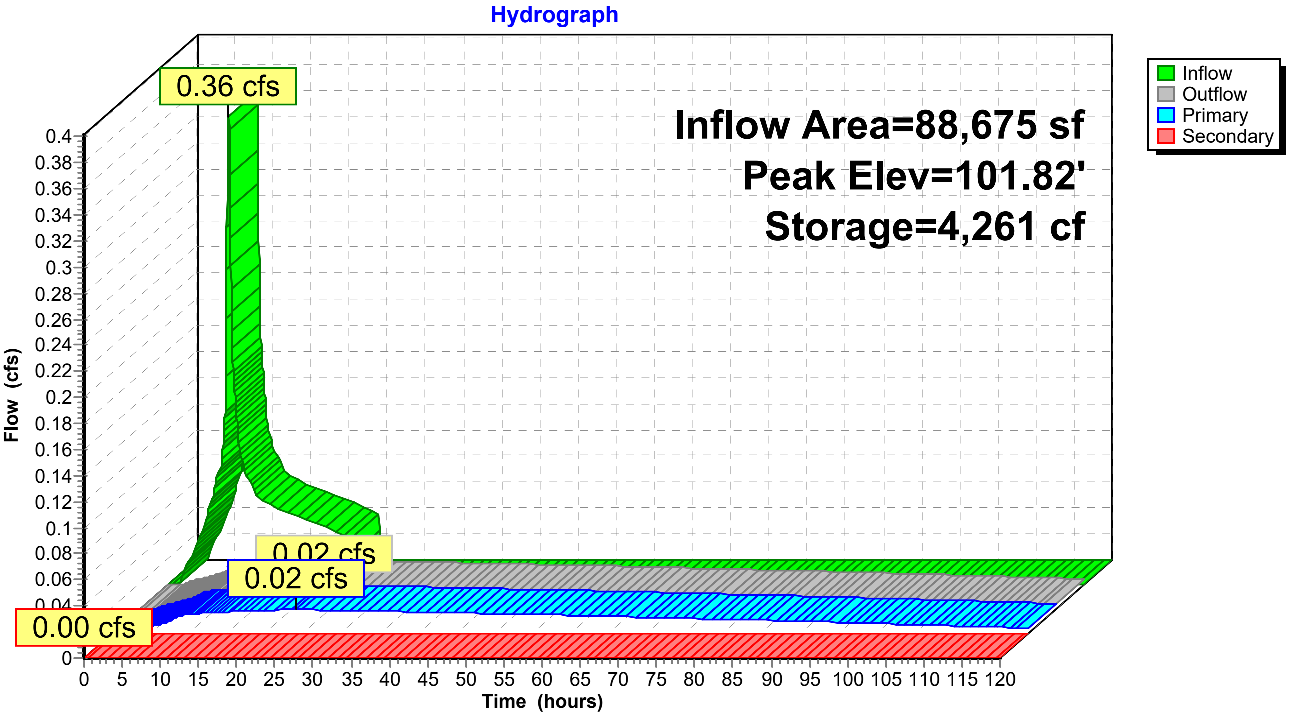
Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
100.00	1,763	0.0	0	0	1,763
103.00	3,910	100.0	8,299	8,299	4,000

Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**0.72" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	101.83'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.02 cfs @ 24.14 hrs HW=101.82' (Free Discharge)
↑**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 6.50 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=100.00' (Free Discharge)
↑**2=Orifice/Grate** (Controls 0.00 cfs)

Pond 8P: WQ


Hydrograph
0.36 cfs
0.02 cfs
0.02 cfs
0.00 cfs
Inflow Area=88,675 sf
Peak Elev=101.82'
Storage=4,261 cf
Inflow
Outflow
Primary
Secondary
Flow (cfs)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
0.22
0.24
0.26
0.28
0.3
0.32
0.34
0.36
0.38
0.4
Time (hours)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

Summary for Pond 17P: (new Pond)

[57] Hint: Peaked at 93.06' (Flood elevation advised)

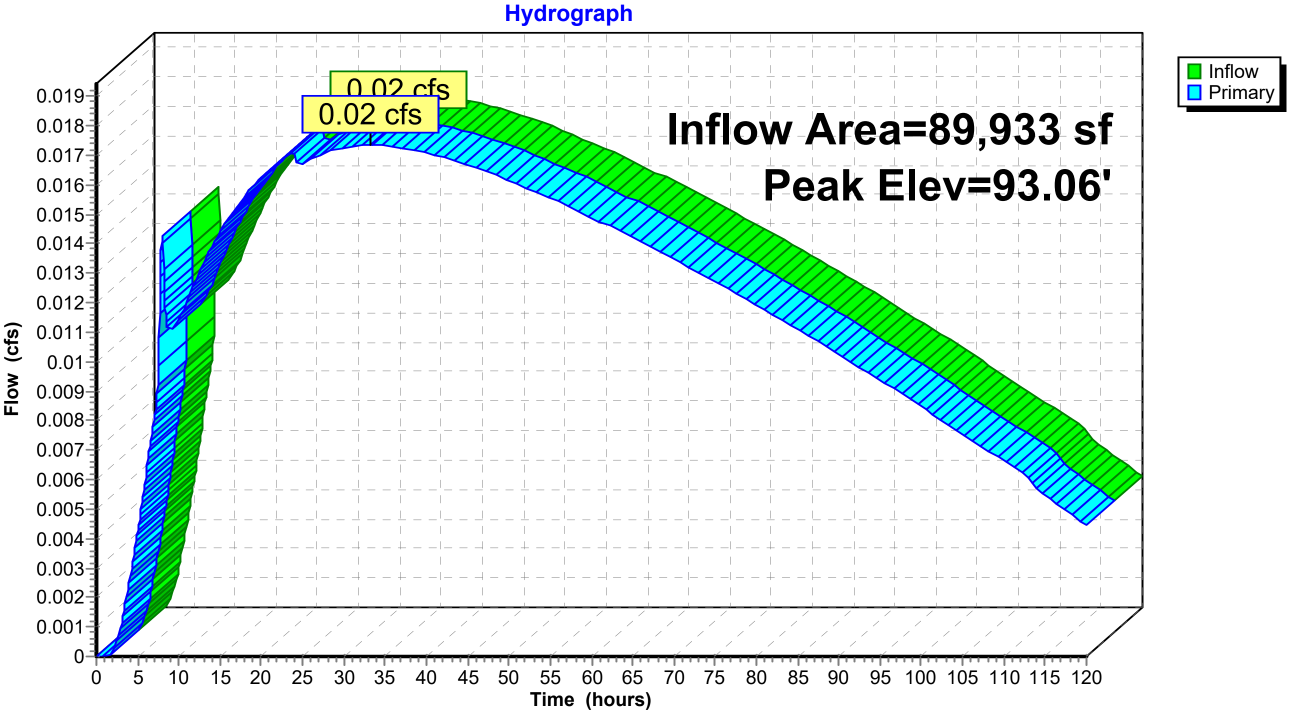
```
Inflow Area =        89,933 sf,  69.63% Impervious,  Inflow Depth >  0.70"   for  WQ-HUD event
Inflow      =       0.02 cfs @   33.14 hrs,  Volume=            5,264 cf
Outflow     =       0.02 cfs @   33.14 hrs,  Volume=            5,264 cf,  Atten= 0%,  Lag= 0.0 min
Primary     =       0.02 cfs @   33.14 hrs,  Volume=            5,264 cf
```

Routing by Stor-Ind method, Time Span= 0.00-120.00 hrs, dt= 0.05 hrs
Peak Elev= 93.06' @ 33.14 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	93.00'	**12.00" Vert. Orifice/Grate** C= 0.600

Primary OutFlow Max=0.02 cfs @ 33.14 hrs HW=93.06' (Free Discharge)
└─**1=Orifice/Grate** (Orifice Controls 0.02 cfs @ 0.85 fps)

Pond 17P: (new Pond)



North Basin

$$\text{Water Quality Volume} = \frac{0.36\ (\text{in}) \times 63{,}615\ (\text{ft}^2)}{12\ (\text{in/ft})} = 1{,}908.5\ \text{ft}^3$$

$$\text{Water Quality Flow} = \frac{1{,}908.5\ (\text{ft}^3)}{14{,}400\ (\text{sec})} = 0.133\ (\text{ft}^3/\text{sec})$$

$$Q = \frac{1{,}908.5\ (\text{ft}^3)}{48\ (\text{hr}) \times 60\ (\text{min/hr}) \times 60\ (\text{sec/min})} = 0.011\ (\text{ft}^3/\text{sec})$$

$$H = 2/3 \times \frac{1{,}908.5\ (\text{ft}^3)}{1{,}722\ (\text{ft}^2)} = 0.74\ \text{ft}$$

$$\text{Orifice Size} = 24 \times [(0.011\ (\text{ft}^3/\text{sec}) / (0.62(2 \times 32.2 \times 0.74)^{0.5}) / \pi\ ]^{0.5} = 0.71\ \text{in}$$

South Basin

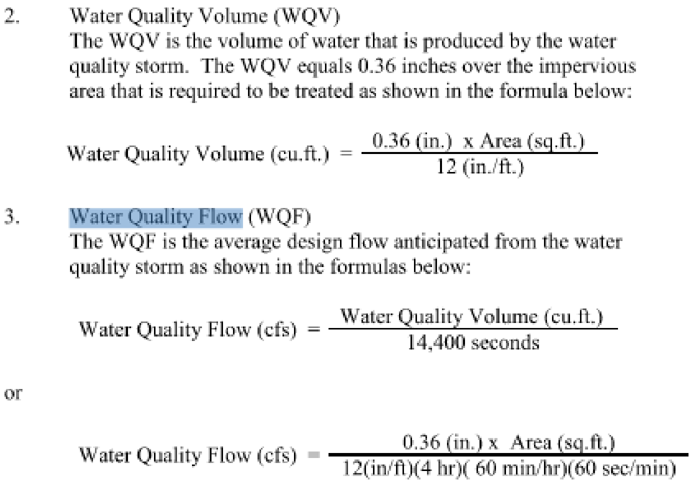
$$\text{Water Quality Volume} = \frac{0.36\ (\text{in}) \times 61{,}366\ (\text{ft}^2)}{12\ (\text{in/ft})} = 1{,}841.0\ \text{ft}^3$$

$$\text{Water Quality Flow} = \frac{1{,}841.0\ (\text{ft}^3)}{14{,}400\ (\text{sec})} = 0.128\ (\text{ft}^3/\text{sec})$$

$$Q = \frac{1{,}841.0\ (\text{ft}^3)}{48\ (\text{hr}) \times 60\ (\text{min/hr}) \times 60\ (\text{sec/min})} = 0.011\ (\text{ft}^3/\text{sec})$$

$$H = 2/3 \times \frac{1{,}841.0\ (\text{ft}^3)}{2{,}016\ (\text{ft}^2)} = .61\ \text{ft}$$

$$\text{Orifice Size} = 24 \times [(0.011\ (\text{ft}^3/\text{sec}) / (0.62(2 \times 32.2 \times 0.61)^{0.5}) / \pi\ ]^{0.5} = 0.72\ \text{in}$$



2. Water Quality Volume (WQV)
The WQV is the volume of water that is produced by the water quality storm. The WQV equals 0.36 inches over the impervious area that is required to be treated as shown in the formula below:

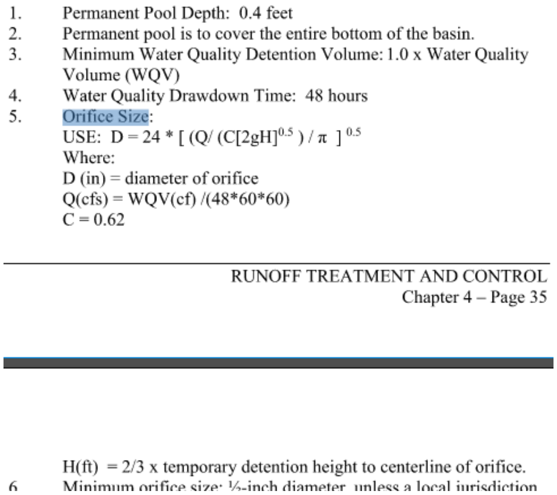
$$\text{Water Quality Volume (cu.ft.)} = \frac{0.36\ (\text{in.}) \times \text{Area (sq.ft.)}}{12\ (\text{in./ft.})}$$

3. Water Quality Flow (WQF)
The WQF is the average design flow anticipated from the water quality storm as shown in the formulas below:

$$\text{Water Quality Flow (cfs)} = \frac{\text{Water Quality Volume (cu.ft.)}}{14{,}400\ \text{seconds}}$$

or

$$\text{Water Quality Flow (cfs)} = \frac{0.36\ (\text{in.}) \times \text{Area (sq.ft.)}}{12(\text{in/ft})(4\ \text{hr})(60\ \text{min/hr})(60\ \text{sec/min})}$$



1. Permanent Pool Depth: 0.4 feet
2. Permanent pool is to cover the entire bottom of the basin.
3. Minimum Water Quality Detention Volume: 1.0 x Water Quality Volume (WQV)
4. Water Quality Drawdown Time: 48 hours
5. Orifice Size:
USE: $D = 24 * [\ (Q/\ (C[2gH]^{0.5}\ ) / \pi\ ]^{0.5}$
Where:
D (in) = diameter of orifice
Q(cfs) = WQV(cf) /(48*60*60)
C = 0.62

RUNOFF TREATMENT AND CONTROL
Chapter 4 – Page 35

H(ft) = 2/3 x temporary detention height to centerline of orifice.
6. Minimum orifice size: ½-inch diameter, unless a local jurisdiction

Appendix D: Additional Forms

TR55 Curve Runoff Numbers

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

---

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

---------- Cover description ----------			---------- Curve numbers for hydrologic soil group ----------			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

[1] Average runoff condition, and $I_a = 0.2S$.

[2] *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

[3] *Poor*: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

[4] Actual curve number is less than 30; use CN = 30 for runoff computations.

[5] CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

[6] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2]	A [3]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

[1] Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.

[2] Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.

[3] Curve numbers for group A have been developed only for desert shrub.

Appendix E: Associated Reports

Downstream Analysis
Geotechnical Report

Downstream Analysis

Plambeck Gardens

23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon 97062

Date:
May 2, 2022

Prepared by Alex Wesolovski

STORMWATER CONVEYANCE CALCULATIONS

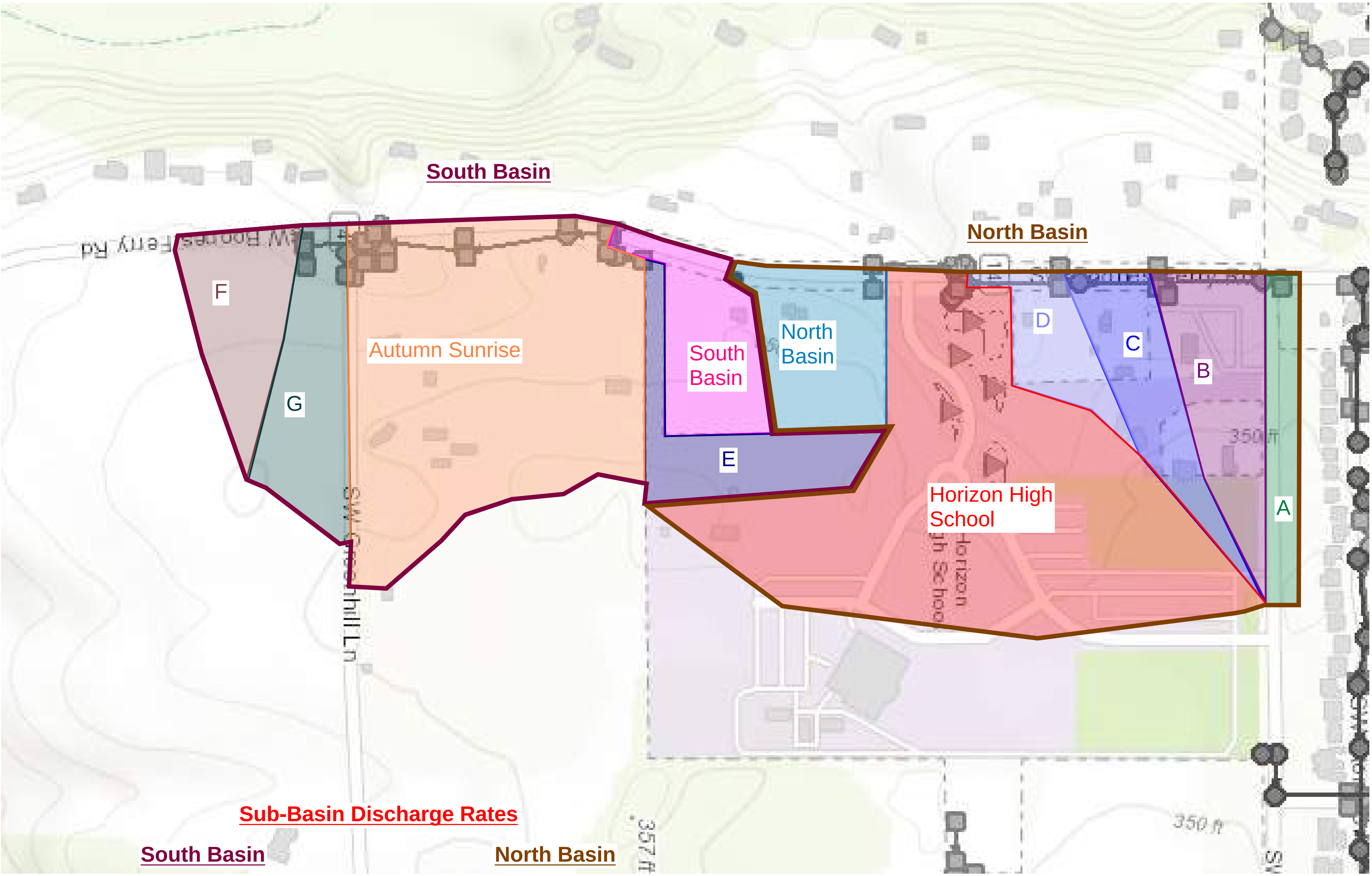
Design Storm: 25 YR
Storm Duration: 24 HRS
Precipitation: 3.9 IN
Manning's "n" 0.013 (FOR PVC STORM PIPE)

LINE	INC. AREA (AC)	INC. % IMP.	CUM. AREA TOTAL (AC)	CUM. AREA PERV. (AC)	CN PER.	CUM. AREA IMP. (AC)	CN IMP.	TIME (MIN)	Q (CFS)	PIPE Dia. (IN)	SLOPE (FT/FT)	Qf (CFS)	Q/Qf (%)	Depth (in)	Depth/ Dia.	V (fps)	LENGTH (FT)	INC. TIME (MIN)
North Basin - Project Site								5.00	0.31	12	0.02	5.05	0.06	2.02	0.17	3.56	296.0	1.39
A	0.574	100	0.5740		61	0.5740	98	5.00	0.59	15	0.02	9.16	0.06	2.57	0.17	4.18	274.0	1.09
B	4.800	25.00	5.3740	4.8000	61	1.2000	98	6.09	2.11	15	0.0200	9.16	0.23	4.90	0.33	6.05	205.0	0.56
C	2.610	13.00	7.9840	7.6447	61	0.3393	98	6.66	3.03	15	0.0200	9.16	0.33	5.95	0.40	6.69	56.0	0.14
D	1.470	30.00	9.4540	9.0130	61	0.4410	98	6.80	4.15	18	0.0200	14.89	0.28	6.50	0.36	7.20	318.0	0.74
Horizon High School	15.100	30.00	24.5540	20.0240	61	4.5300	98	7.53	5.77									
						North Basin, Total			10.54									

STORMWATER CONVEYANCE CALCULATIONS

Design Storm: 25 YR
Storm Duration: 24 HRS
Precipitation: 3.9 IN
Manning's "n" 0.013 (FOR PVC STORM PIPE)

LINE	INC. AREA (AC)	INC. % IMP.	CUM. AREA TOTAL (AC)	CUM. AREA PERV. (AC)	CN PER.	CUM. AREA IMP. (AC)	CN IMP.	TIME (MIN)	Q (CFS)	PIPE Dia. (IN)	SLOPE (FT/FT)	Qf (CFS)	Q/Qf (%)	Depth (in)	Depth/ Dia.	V (fps)	LENGTH (FT)	INC. TIME (MIN)
south basin - Project Site									0.24									
E	3.970	12.00	3.9700	3.4936	61	0.4764	98	5.00	0.98	12	0.0200	5.05	0.19	3.59	0.30	4.97	609.0	2.04
F	3.900	14.50	7.8700	7.3045	61	0.5655	98	7.04	2.08	15	0.0200	9.16	0.23	4.87	0.32	6.03	102.0	0.28
G	2.630	11.00	10.5000	10.2107	61	0.2893	98	7.32	1.05	12	0.0200	5.05	0.21	3.72	0.31	5.07	248.0	0.82
Autumn Sunrise									15.22	24	0.0200	32.08	0.47	11.66	0.49	10.06	78.0	0.13
				South Drainage Basin, Total					19.57									



Sub-Basin Discharge Rates

South Basin

South Basin = 0.24cfs
E = 0.74cfs
Autumn Sunrise = 14.17cfs
F = 1.10cfs
G = 1.05cfs

North Basin

A = 0.28cfs
B = 1.52cfs
C = 0.92cfs
D = 1.12cfs
Horizon High School = 5.77cfs
North Basin = 0.31cfs

Downstream Analysis Basin Map

Earth
Engineers,
Inc.

2411 Southeast 8th Avenue ● Camas ● WA 98607
Phone: 360-567-1806
www.earth-engineers.com

March 17, 2021

Community Partners for Affordable Housing
P.O. Box 23206
Tigard, Oregon 97239
Attention: Jilian Saurage Felton, Housing Development Director

Phone: 503-293-4038
E-mail: jsaurage@cpahoregon.org

Subject: **Geotechnical Investigation Report**
Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon
EEI Report No. 21-023-1

Dear Ms. Saurage Felton:

Earth Engineers, Inc. (EEI) is pleased to provide our attached Geotechnical Investigation Report for the above referenced project. This report includes the results of our field investigation, an evaluation of geotechnical factors that may influence the proposed construction, and geotechnical recommendations for the proposed structure and general site development.

We appreciate the opportunity to perform this geotechnical study and look forward to continued participation during the design and construction phases of this project. If you have any questions pertaining to this report, or if we may be of further service, please contact our office at 360-567-1806.

Sincerely,
Earth Engineers, Inc.

Anita Bauer

Troy Hull, P.E., G.E.
Principal Geotechnical Engineer

Anita Bauer
Geologic Associate

Attachment: Geotechnical Investigation Report

Distribution: Addressee
Rachel Loftin, CPAH (rloftin@cpahoregon.org)
Melissa Soots, Carlton Hart Architecture (Melissa.soots@carltonhart.com)

GEOTECHNICAL INVESTIGATION REPORT

for the

Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon

Prepared for

Community Partners for Affordable Housing
P.O. Box 23206
Tigard, Oregon 97239

Prepared by

Earth Engineers, Inc.
2411 Southeast 8th Avenue
Camas, Washington 98607
Telephone (360) 567-1806

EEI Report No. 21-023-1

March 17, 2021

Anita Bauer

Anita Bauer
Geologic Associate

19206PE
OREGON
JULY 15, 1997
TROY M. HULL
EXPIRES: 6/30 21

Troy Hull, P.E., G.E.
Principal Geotechnical Engineer

TABLE OF CONTENTS

1.0 PROJECT INFORMATION

1.1 Project Authorization

Earth Engineers, Inc. (EEI) has completed a geotechnical investigation report for the proposed Basalt Creek affordable housing project to be located at 23500 and 23550 Southwest Boones Ferry Road in Tualatin, Washington County, Oregon. Our geotechnical services were authorized by Jilian Saurage Felton, Housing Development Director for Community Partners for Affordable Housing (CPAH) on February 3, 2021 by signing EEI Proposal No. 21-P004-R1 dated January 20, 2021.

1.2 Project Description

Our current understanding of the project is based on information Rachel Loftin with CPAH, Melissa Soots with Carleton Hart Architecture (CHA) and Kim Shera with Vega Civil provided to EEI Principal Geotechnical Engineer Troy Hull. The following are the most up-to-date documents provided to us:

- **Undated Preliminary Site Plan, Sheet A0.00, by Carleton Hart Architecture, received by e-mail on February 17, 2021.** This drawing replaced 2 previous drawings by CHA dated May 15, 2020 that shows the locations of test pits and infiltration test locations.

Briefly, we understand the project will consist of demolishing the 2 existing homes on the 2 lots and constructing a multi-family housing complex consisting of the following:

- Three, 3-story residential buildings (A, B, and C) that are anticipated to have floor slabs on grade.
- A community building. We assume this will be 1 or 2 stories and have a floor slabs on grade.
- 3 detached garage buildings
- Paved parking and drive lanes, including some permeable pavement.

We have not been provided any foundation load information. For the purposes of this report, we are assuming maximum foundation loads of 6 kips per linear foot for wall footings, 60 kips for column footings, and 150 psf for floor slabs. Other than underground utilities, we assume there will be no below grade construction. We assume cuts and fills will generally be no greater than about 2 feet. Finally, we have assumed that the buildings will be constructed in accordance with the 2019 Oregon Structural Specialty Code (OSSC), an amendment to the 2018 International Building Code (IBC).

As far as stormwater disposal is concerned, we understand the current plan is to use permeable pavement at the north end of the project (beneath a sport court) and in the parking stalls, and surface infiltration in storm swales along the west edge and middle of the project.

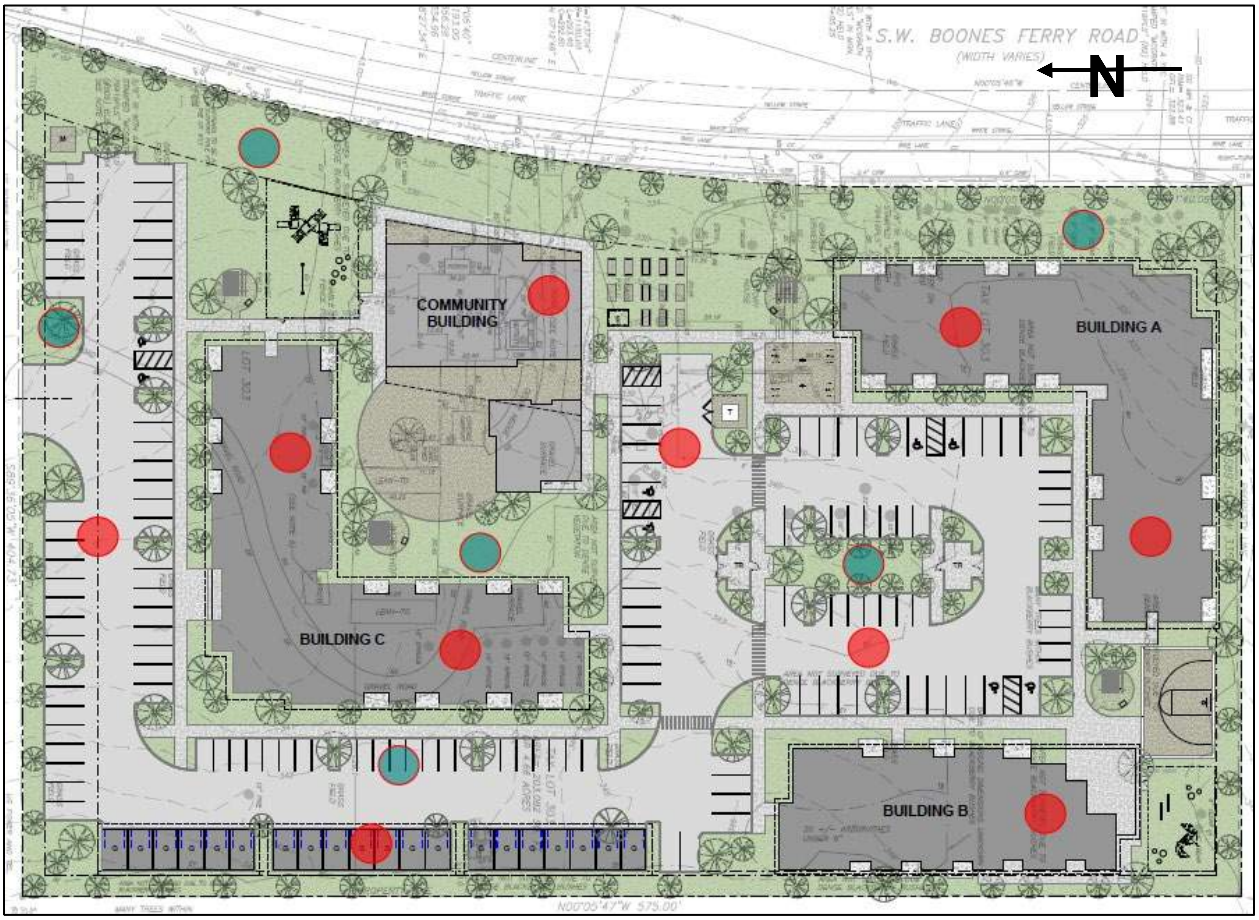


Figure 1: Proposed site plan (source: undated Sheet A0.00 by Carleton Hart Architecture).

1.3 Purpose and Scope of Services

The purpose of our services was to explore the subsurface conditions at the site to better define the existing soil, rock, and groundwater properties in order to provide geotechnical related recommendations for the proposed new building construction. Our site investigation consisted of excavating 10 test pits (TP-1 to TP-10) to depths ranging from 7 to 10 feet below ground surface (bgs) with a Hitachi Zaxis 40U excavator subcontracted from Dan Fischer Excavating. Drive probe testing was performed adjacent to test pits TP-1 through TP-7 to better characterize the soil strength. The approximate test pit locations are shown in Appendix B. Grab soil samples were samples were obtained at the discretion of the Geotechnical Engineer’s field representative and returned to our office for testing.

Our site investigation scope also included infiltration testing in general accordance with Clean Water Services at the locations specified by Vega Civil.

Laboratory testing was performed on select grab samples to determine the material properties for our evaluation and, in general accordance with ASTM procedures. This included moisture content (ASTM D2216), material finer than #200 Sieve - washed (ASTM D1140), Atterberg limits (ASTM D4318), and classification of soils by the Unified Soil Classification System [USCS] (ASTM D2487 and D2488).

This report briefly outlines the testing procedures, presents available project information, describes the site and subsurface conditions, and presents recommendations regarding the following:

- A discussion of subsurface conditions encountered including pertinent soil and groundwater conditions.
- Seismic design parameters in accordance with the 2019 OSSC and ASCE 7-16.
- Geotechnical related recommendations for foundation design including allowable bearing capacity, minimum footing dimensions and estimated settlements.
- Structural fill recommendations, including an evaluation of whether the in-situ soils can be used as structural fill.
- Grading recommendations, including special considerations for wet weather grading.
- Retaining wall design parameter recommendations, including coefficient of friction and earth pressures.
- Floor slab support recommendations.
- Pavement section thickness recommendations based on an assumed CBR value and assumed traffic loading conditions.
- Results of our infiltration testing to aid the project Civil Engineer in designing the on-site stormwater disposal system.
- Other discussion on geotechnical issues that may impact the project.

2.0 SITE AND SUBSURFACE CONDITIONS

2.1 Site Location and Description

The property is located at 23500 and 23550 Southwest Boones Ferry Road in Tualatin, Washington County, Oregon. The subject property is bordered by Southwest Boones Ferry Road to the west, an existing residence and New Horizon Church to the east, the driveway access for New Horizon Church to the north, and a large field to the south.

In terms of topography, the subject property mostly is generally level to slightly sloping. There is a large fill mound that is several feet high at the north edge of the property. The property is generally covered with grass, bushes, and young and mature trees. See Photos 1 through 5 below for the site conditions.

Photo 1: Looking west from the east-central portion of the site at an existing barn structure to be demolished.

Photo 2: Looking south from the northwest corner of the project site at an existing house to be demolished.

Photo 3: Looking west at the fill mound at the north end of the site.

Photo 4: Looking north at the west property boundary along Southwest Boones Ferry Road.

Photo 5: Looking northeast at the project site from the southwest corner of the property.

2.2 Mapped Soils and Geology

The subject property is regionally located on the east side of Parrett Mountain and the Chehalem Mountain range that separates the sediment filled Tualatin and Northern Willamette Valley drainage basins. The subject property is bordered by the Tualatin Basin to the north, the Northern Willamette Valley Basin to the south, Parrett Mountain to the west and the Portland Hills to the northeast. The Portland Hills, Chehalem Mountain range, and Parrett Mountain are relatively small mountain ranges composed of Miocene aged (23 to 5 million years ago) basalt from the Columbia River Basalt Group (CRBG) that had been folded and uplifted around the Tualatin Basin during the late Neogene (roughly 3 million years ago)[1].

In the vicinity of the subject property, the underlying geology is mapped as the Sentinel Bluffs Member (Tgsb) which is an informal unit of Miocene aged Grande Ronde Basalt and part of the Columbia River Basalt Group. Pleistocene aged (2.6 million to 11,700 years ago) Missoula flood deposits (Qf) are also mapped in the area. The Sentinel Bluffs Member consists of light to dark gray, columnar-jointed basalt with vesicular flow tops. Weathered surfaces are greenish gray to pale gray and the unit thickness typically ranges from about 30 to 75 feet. Missoula flood deposits (Qf) consist of unconsolidated stratified clay, silt, sand and gravel that originated from Lake Missoula, flowed down the Columbia River and flooded the Tualatin and Willamette Valley Basins[2].

The surface soils on the project site are mapped by the US Soil Survey as Unit 28B: Laurelwood silt loam on 3 to 7 percent slopes. This soil is formed on hills and comes from a loess (i.e. wind-blown) parent material. A typical profile for this unit consists of silt loam approximately 0-11 inches bgs, followed by silty clay loam 11-52 inches bgs, and overlying silty clay 52 to 72 inches bgs. This typically well-drained soil has a moderately high transmissivity of water (0.20 to 0.57 inches per hour)[3].

We reviewed the Oregon Department of Geology and Mineral Industries (DOGAMI) Statewide Geohazards Information Database for Oregon (HazVu) website (https://gis.dogami.oregon.gov/hazvu/ to report the applicable hazards for the subject property. This database maps the property within a very strong to sever expected earthquake shaking hazard and very strong Cascadia earthquake expected shaking. In addition, the subject property's proximity to the Canby-Molalla fault is approximately 3.3 miles to the northeast; see Figure 2 below. The Canby-Molalla fault is moderately constrained, late Quaternary (<130,000 years) in age, has a right lateral slip sense

---

[1] D.K. McPhee, V.E. Langenheim, R.E. Wells, R.J. Blakely; Tectonic evolution of the Tualatin basin, northwest Oregon, as revealed by inversion of gravity data. *Geosphere* 2014;; 10 (2): 264–275. doi:

[2] Wells, R.E., Haugerud, R.A., Niem, A.R., Niem, W.A., Ma, L., Evarts, R.C., O'Connor, J.E., Madin, I.P., Sherrod, D.R., Beeson, M.H., Tolan, T.L., Wheeler, K.L., Hanson, W.B., and Sawlan, M.G., 2020, Geologic map of the greater Portland metropolitan area and surrounding region, Oregon and Washington: U.S. Geological Survey Scientific Investigations Map 3443, pamphlet 55 p., 2 sheets, scale 1:63,360, https://doi.org/10.3133/sim3443.

[3] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/ accessed 3/16/2021.

with a slip rate of less than 0.2mm/year[4]. The database also maps the subject property within moderate landslide susceptibility on the north end of the property. It should be noted that the surrounding, previously developed properties are also mapped within these same hazards.

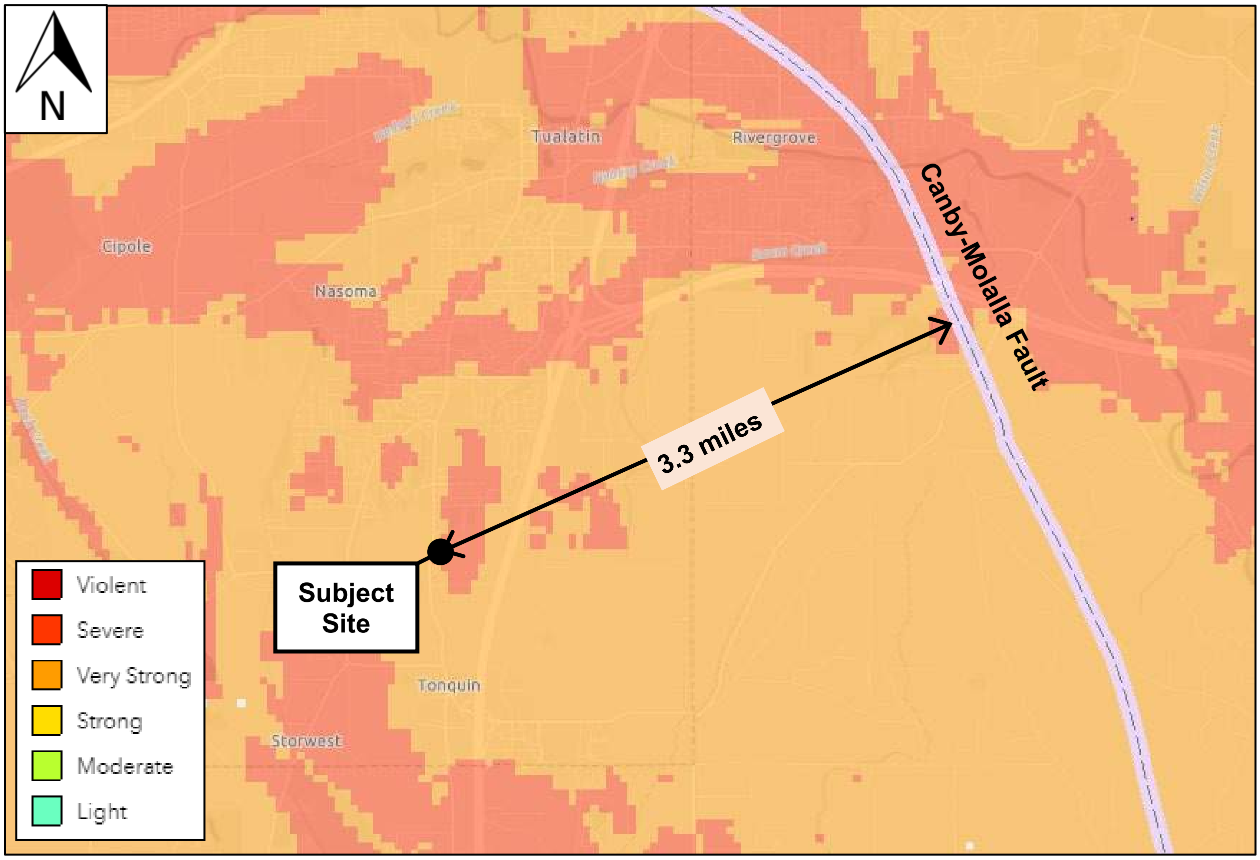


Figure 2: Earthquake hazard map of the subject property and vicinity (base map source: DOGAMI HazVu).

2.3 Subsurface Materials

The subsurface conditions at the site were explored with 10 test pits (TP-1 through TP-10) excavated with a Hitachi Zaxis 40U excavator to depths ranging from 7 to 10 feet bgs. To better characterize the soil strengths, we performed drive probe testing adjacent to test pits TP-1 through TP-7. The drive probe test is based on a “relative density” exploration device used to determine the distribution and to estimate strength of the subsurface soil units. The resistance to penetration is measured in blows-per-½-foot of an 11-pound hammer which free falls roughly 3½ feet driving a 1-inch diameter pipe into the ground. This measure of resistance to penetration can be used to

---

[4] United States Geologic Survey, U.S. Quarternary Faults database. Available online at https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=5a6038b3a1684561a9b0aadf88412fcf accessed 3/16/21

estimate relative density of soils. For a more detailed description of this geotechnical exploration method, please refer to the Slope Stability Reference Guide for National Forests in the United States, Volume I, USDA, EM-7170-13, August 1994, P 317-321. The drive probe test results are summarized in the test pit logs in Appendix C.

Disturbed “grab” soil samples were obtained in the test pits from each major soil stratum. The soil samples were tested in the laboratory to determine material properties for our evaluation. Laboratory testing was accomplished in accordance with ASTM procedures which included moisture content tests (ASTM D2216), fines content determinations (ASTM D1140), and Atterberg limits (ASTM D4318). The test results have been included on the Exploration Logs in Appendix C.

In general, we encountered topsoil overlying native fine-grained soils (i.e. silt and clay) that graded to decomposed/intensely weathered basalt with increasing depth In a few isolated locations, we encountered existing fill soil. Each of the strata we encountered in our exploration are described individually below:

Topsoil – Topsoil was encountered in all of the test pits, except TP-5 and TP-9, which were located in the fill mound at the north end of the project site. The topsoil generally consisted of dark brown sandy silt with roots, occasional gravels, and ranged in thickness from about 6 inches to 2 feet. It should also be noted we did encounter some old PVC irrigation pipes within the upper 2 feet throughout the site.

Fill – Fill was encountered in test pits TP-5 through TP-10. The fill in TP-5 and TP-9 was from a fill mound (i.e. stockpile). The fill soil in the test pits in general consisted of silt with organics (i.e. roots and rootlets), asphalt chunks, gravel and cobble size rocks, and trace charcoal and brick fragments. The fill in our test pits extended to a depth below the general site grade of 1.5 to 3.5 feet bgs.

Silt (ML) - Below the surficial topsoil and fill layers, we encountered soft to very stiff, brown with some orange and black mottling, silt. Moisture contents of the samples tested ranged from 24 to 31 percent, indicating the soils are generally moist to wet.

Elastic Silt (MH) – Generally below the silt (ML) layer, we encountered a high plasticity silt starting at a depth of 2.5 to 7.5 feet bgs. This soil unit was brown to reddish brown and medium stiff to hard. Moisture contents of the samples tested ranged from 26 to 49 percent, indicating the soils are generally moist to wet. An Atterberg limits test on this material indicated a Liquid Limit (LL) of 54, Plastic Limit (PL) of 23, and a Plasticity Index (PI) of 31. Based on this test result, we consider this soil to be moderately expansive and to have moderate risk of heaving and shrinking due to moisture change. This soil unit graded from decomposed to intensely weathered basalt bedrock with increasing depth. Where the test pits indicate the digging became “hard” at depth, we interpret that to be the less weathered basalt bedrock stratum. That depth generally ranged from about 6.5 to 8.5 feet bgs in our test pits.

The classifications noted above were made in general accordance with the USCS as shown in Appendix D. The above subsurface description is of a generalized nature to highlight the major subsurface stratification features and material characteristics. The exploration logs included in the Appendix should be reviewed for specific information at specific locations. These records include soil descriptions, stratifications, and locations of the samples. The stratifications shown on the logs represent the conditions only at the actual exploration locations.

The fill extent at each boring location was estimated based on an examination of the soil samples, the presence of foreign materials, field measurements, and the subsurface data. The explorations performed are not adequate to accurately identify the full extent of existing fill across the site. Consequently, the actual fill extent may be much greater than that shown on the exploration logs and discussed herein.

Soil variations may occur and should be expected between locations. The stratifications represent the approximate boundary between subsurface materials and the actual transition may be gradual. Water level information obtained during field operations is also shown on these logs. The samples that were not altered by laboratory testing will be retained for 90 days from the date of this report and then will be discarded.

2.4 Groundwater Information

Groundwater was encountered in all of our test pits except TP-8 and TP-9. The depth of groundwater ranged from 4 to 7.5 feet bgs. We do anticipate that the relatively shallow depth to groundwater could potentially impact the proposed construction. It should be noted that groundwater elevations can fluctuate annually and seasonally, especially during periods of extended wet or dry weather, or from changes in land use.

2.5 Seismicity

In accordance with Section 1613.2.2 of the 2019 OSSC and Table 20.3-1 of ASCE 7-16, we recommend a Site Class D (stiff soil profile with an average standard penetration resistance of between 15 and 50 blows per foot) when considering the average of the upper 100 feet of bearing material beneath the proposed foundations. This recommendation is based on our observations in the test pits, our drive probe test data, as well as our local knowledge of the area geology. Inputting our recommended Site Class as well as the site latitude and longitude into the Structural Engineers Association of California (SEAOC) – OSHPD Seismic Design Maps website (http://seismicmaps.org) which is based on the United States Geological Survey, we obtained the seismic design parameters shown in Table 1 below.

Table 1: Seismic Design Parameter Recommendations (ASCE 7-16)

PARAMETER	RECOMMENDATION
Site Class	D
S_s	0.830g
S_1	0.386g
F_a	1.168
F_v	Null – See Section 11.4.8
S_{MS} (=S_s x F_a)	0.970g
S_{M1} (=S_1 x F_v)	Null – See Section 11.4.8
S_{DS} (=2/3 x S_s x F_a)	0.646g
Design PGA (=S_{DS} / 2.5)	0.258g
MCE_G PGA	0.378g
F_{PGA}	1.222
PGA_M (MCE_G PGA * F_{PGA})	0.462g

Note: Site latitude = Latitude 45.3502154, longitude = Longitude -122.77435

The return interval for the ground motions reported in the table above is 2 percent probability of exceedance in 50 years.

Per Section 11.4.8 of ASCE 7-16 a site-specific seismic site response is required for structures on Site Class D and E sites with S_1 greater than or equal to 0.2g. The S_1 value for this site is greater than 0.2g as shown in Table 1 above. Therefore a site response analysis is required as part of the design phase. However, Section 11.4.8 does provide an exception for not requiring a site response analysis (reference Sections 11.4.8.1, 11.4.8.2 and 11.4.8.3). The project Structural Engineer should determine if the proposed buildings will meet any of the exceptions—if the buildings do not meet the exception requirements then EEI should be retained to perform a site-specific site response analysis.

We understand a Supplement 1 dated December 12, 2018 has been issued for ASCE 7-16 to correct some issues in the original publication. One of the corrections in the Supplement pertains to Table 11.4-2 (see table below) for determining the value of the Long-Period Site Coefficient, F_V, which is then used to calculate the value of T_S. The T_S value is needed for one of the exceptions in Section 11.4.8. Without the correction in Supplement 1, it would not be possible to determine F_V and calculate T_s. Based on Supplement 1, the F_V value may be determined from the following corrected table.

Table 2: Long-Period Site Coefficient, F_V (corrected Table 11.4-2 in ASCE 7-16).

	Mapped Risk-Targeted Maximum Considered Earthquake (MCE_R) Spectral Response Acceleration Parameter at 1-s Period					
Site Class	S_1<=0.1	S_1<=0.2	S_1<=0.3	S_1<=0.4	S_1<=0.5	S_1>=0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	**2.2**[a]	**2.0** [a]	**1.9** [a]	**1.8** [a]	**1.7** [a]
E	4.2	**3.3** [a]	**2.8** [a]	**2.4** [a]	**2.2** [a]	**2.0** [a]
F	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8	See Section 11.4.8

Note: use linear interpolation for intermediate values of S_1.

[a] See requirements for site-specific ground motions in Section 11.4.8. These values of F_V shall be used only for calculation of T_S.

2.6 Infiltration Testing

The infiltration testing was conducted in general accordance with the Clean Water Services requirements for the single ring, falling head test procedure. As requested, a total of 5 test locations (IT-1 through IT-5) were completed. Three separate trials (i.e. standpipes) were performed at each of the 5 test locations. Each test location was cased with a 6-inch diameter PVC pipe and seated at least 4-inches into the bottom of the test pit. Approximately 2-inches of clean gravel was placed in the bottom of the pipes to prevent scouring. 12-inches of water was then placed into the pipes and allowed to drain. Because the 12 inches of water did not drain away in 10 minutes or less, a 4-hour minimum presoak was required for all of the tests performed. After the 4-hour presoak period, we took repeated 30-minute readings with six inches of water in the standpipe until a consistent rate was observed. The location of the infiltration testing can be seen in Appendix B. Disturbed grab samples were taken at the bottom of each test location and soil samples were returned to our laboratory for testing (i.e. moisture content and wash #200).

The results of our lab testing and infiltration tests are shown in Table 3 below. The infiltration test results should be considered ultimate values and do not include a factor of safety. Clean Water Services recommends a factor of safety of 2. We recommend that during construction, field verification testing be performed to confirm the actual infiltration rates are consistent with the values in Table 3 below.

Photo 6: Setting the 3 standpipes in the test pit trench at one of the infiltration test locations.

Photo 7: Backfilling around the 3 standpipes in the test pit trench at one of the infiltration test locations prior to conducting the infiltration testing.

Table 3: Summary of Infiltration Test Results.

Test #	Test Depth, bgs (inches)	Soil Description	% Fines	% Moisture	Tested Infiltration Rate (inches/hour)*
IT-1a	24	Silt	90	28	0.5
IT-1b	30		76	28	2.0
IT-1c	30		92	28	5.2
IT-2a	28	Silt	89	26	8.2
IT-2b	30		88	27	6.0
IT-2c	24		91	22	2.2
IT-3a	24	Silt	94	28	1.0
IT-3b	36		94	29	5.5
IT-3c	36		94	30	19.3
IT-4a	24	Silt	91	29	40.5
IT-4b	36		91	27	22.0
IT-4c	39		91	27	9.2
IT-5a	24	Silt	92	26	6.8
IT-5b	33		92	27	1.7
IT-5c	30		92	28	7.2

*No safety factors have been applied to the test rates above.

3.0 EVALUATION AND FOUNDATION RECOMMENDATIONS

3.1 Geotechnical Discussion

It is our professional opinion that the following factors may influence the proposed construction:

1. **Presence of existing fill soils** – We encountered fill soils below existing grade generally throughout the property, as well as at a large fill mound at the north end of the project. At least some of the fill encountered below existing grade appears to be grading for the driveways and home developments. The fill mound at the north end of the property appears to be stockpiled soil. Some of the fill appeared firm and well compacted, while some was very soft and poorly compacted. In general, the fill closer to the ground surface was more firm, presumably from past vehicular traffic driving over it. Excluding the fill mound, the fill was generally 1.5 to 3.5 feet deep. However, it should be assumed that the fill soils could be variable across the property.

   Because of the variability in strength (i.e. compaction), we recommend structures not be supported directly on the existing fill soils. One mitigation option would be recompact all of the existing fill beneath all building structures (i.e. footings and slabs). Another option would be to limit the overexcavation to the native soils just beneath footing areas and only do a partial overexcavation beneath floor slabs to reduce the risk of future floor slab settlement. This second option carries more risk of settlement cracking for the floor slab areas, but reduces the construction cost.

   The fill mound material appears generally suitable for use as fill. Ideally, it would be limited to landscape fill areas because it contains some organics. However, it could be used for structural fill provided the organic material is removed. Some minor (i.e. less than 5 percent) organics (i.e. rootlets) would be acceptable in the structural fill, but larger quantities of organics would need to be removed. Note that we only performed 2 test pits in the fill mound area so there is a large percentage of the mound that we did not investigate. If the contractor will rely on using the fill mound material in their construction cost, we recommend they consider further investigating the contents of the mound.

2. **Presence of soft native soils** – The near-surface native silt soils in our test pits were generally soft. They are appropriate for supporting the proposed buildings, but will have a relatively low allowable soil bearing pressure (i.e. 1,500 pounds per square foot). Firmer (stiff) silt soils were encountered at a depth of 5 to 6 feet below grade. If a higher allowable soil bearing pressure (i.e. 2,500 psf) is desired, the footings could be overexcavated to this stiff soil stratum and then backfilled up to bottom of footing grade. Or rammed aggregate piers designed and installed by a geotechnical specialty contractor could also be used to achieve the same thing and also provide for a much higher allowable bearing capacity (i.e. on the order of 5,000 to 6,000 psf). One consideration with the overexcavation option is that groundwater may be encountered in the footing

overexcavations depending upon the time of year. We anticipate that during the summer months, the risk of groundwater interfering with footing overexcavations will be less.

3. **Presence of potentially expansive soils** – Based on our Atterberg limits testing, the clayey silt (MH) soils first encountered below a depth of about 2.5 to 7.5 feet bgs in our test pits are moderately expansive. It will be acceptable to support the proposed structures on this soil. The only mitigation recommendation we are providing is to not let this soil dry out if exposed. If it is exposed during excavation during the warmer months of the year, it should be covered the same day so it is not allowed to dry out.

4. **Shallow groundwater** – As discussed above, we did encounter shallow groundwater in our test pits—generally 4 to 7.5 feet bgs. Deep excavations (i.e. for trenches, etc.) may require dewatering.

5. **Existing buildings to be demolished** – The existing residences and associated improvements will need to be demolished before the proposed construction can begin. It will be important to remove all the construction debris from the site and to backfill any voids with properly compacted structural fill that is approved by a representative of the Geotechnical Engineer.

6. **Moisture sensitive soils** – This project will likely involve a significant amount of earthwork. The fine-grained site soils are sensitive to wet weather conditions. While not required, earthwork is expected to be easier and less expensive if conducted during the dry summer and early fall months.

In summary, it is acceptable to construct the proposed development on this property provided the recommendations in this report are followed.

3.2 General Site Preparation

Prior to the start of grading, we recommend our test pits performed for this report be located, excavated to their bottoms, and backfilled with properly compacted granular structural fill under the observation of a representative of the Geotechnical Engineer.

Existing pavement and structures will need to be demolished and completely removed from the site. Any topsoil, vegetation, roots, organic laden soils, debris, and any other deleterious soils should also be removed from building areas. It should be expected that the depth of these materials may vary across the site. Topsoil in our test pits ranged from about 6 to 24 inches thick. A representative of the Geotechnical Engineer should determine the depth of removal at the time of construction.

Existing utilities will need to be located and rerouted as necessary and any abandoned pipes or utility conduits should be removed or properly capped off to inhibit the potential for subsurface soil erosion. Utility trench excavations should be backfilled with properly compacted structural fill that is constructed as outlined in Section 3.3 of this report.

After stripping and excavating to the proposed subgrade level, as required, building subgrade areas should be observed by a representative of the Geotechnical Engineer and proofrolled with a fully loaded tandem axle dump truck. If the subgrade cannot be accessed with a dump truck to perform a proofroll, then the subgrade will need to be evaluated by a representative of the Geotechnical Engineer by soil probing. Structural fill, as described in Section 3.3 below, should be placed on the prepared subgrade after it has been proofrolled or soil probed. Soils that are observed to be soft or are otherwise judged to be unsuitable should be undercut and replaced with properly compacted structural fill.

As noted in Section 3.1, the brown to red brown clayey silt soils encountered in our test pits at depths of 2.5 to 7.5 feet bgs are moderately potentially expansive. We recommend they be covered the same day if they are exposed during excavation so that they don’t dry out.

3.3 Structural Fill

Any structural fill to be placed should be free of organics or other deleterious materials, have a maximum particle size less than 3 inches, be relatively well graded, and have a liquid limit less than 45 and plasticity index less than 25. In our professional opinion the onsite native low plasticity silt (ML) soils are appropriate for use as structural fill, however they may be difficult to compact without first adjusting the moisture content. As such, it may be more practical to import granular structural fill. Structural fill should be moisture conditioned to within 3 percentage points below and 2 percentage points above optimum moisture as determined by ASTM D1557 (Modified Proctor).

Fill should be placed in relatively uniform horizontal lifts on the prepared subgrade which has been stripped of deleterious materials and approved by the Geotechnical Engineer or their representative. If loose soils exist on the prepared subgrades, they should be re-compacted. Each loose lift should be about 1-foot thick. The type of compaction equipment used will ultimately determine the maximum lift thickness. Structural fill should be compacted to at least 95 percent of the maximum dry density as determined by ASTM D1557. Each lift of compacted engineered fill should be tested by a representative of the Geotechnical Engineer prior to placement of subsequent lifts.

To reiterate, each 12-inch thick lift of structural fill should be tested for compaction by a representative of the Geotechnical Engineer prior to placement of subsequent lifts.

3.4 Foundation Recommendations

Once the site has been properly prepared as discussed above, the proposed buildings can be supported on a conventional shallow foundation system. Spread footings for isolated columns and continuous bearing walls supported on the medium stiff silt soils or on granular structural fill overly the medium stiff silt stratum can be designed for an allowable soil bearing pressure of up to 1,500 psf. The medium stiff silt was generally encountered immediately beneath the existing fill and topsoil.

If the footings will be overexcavated to the stiff silt soil generally encountered 5 to 6 feet below existing grade, then the footings may be designed for an allowable soil bearing pressure for up to 2,500 psf when bearing on the stiff silt or granular structural fill overlying the stiff silt. Note that the actual depth to the stiff silt stratum may be variable, but we expect that the average depth is 5 to 6 feet across the project site.

To be clear, we do not recommend the footings be supported on the existing fill soils as they were variable in strength and could lead to greater than normal settlement.

Our recommended allowable bearing capacity is based on dead load plus design live load, and can be increased by one-third when including short-term wind or seismic loads. Minimum footing dimensions should be 18 inches for continuous wall footings and 24 inches for isolated pad footings.

Lateral frictional resistance between the base of footings and the subgrade can be expressed as the applied vertical load multiplied by a coefficient of friction of 0.32 for concrete foundations bearing directly on the native silt soils or 0.42 when bearing on at least 12 inches of granular structural fill. In addition, lateral loads may be resisted by passive earth pressures based on an equivalent fluid pressure of 300 pounds per cubic foot (pcf) for footings poured “neat” against the dense to medium dense native soils, or properly backfilled structural fill. These are ultimate values—we recommend a factor of safety of 1.5 be applied to the equivalent fluid pressure, which is appropriate due to the amount of movement required to develop full passive resistance. To be clear, no safety factor has been applied to the friction coefficient discussed above.

Exterior footings and foundations in unheated areas should be located at a depth of at least 18 inches below the final exterior grade to provide adequate frost protection. If the additions are to be constructed during the winter months or if the foundation soils will likely be subjected to freezing temperatures after foundation construction, then the foundation soils should be adequately protected from freezing. Otherwise, interior foundations can be located at nominal depths compatible with architectural and structural considerations.

The foundation excavations should be observed by a representative of the Geotechnical Engineer prior to steel or concrete placement to assess that the foundation materials are capable of supporting the design loads and are consistent with the materials discussed in this report. Unsuitable soil zones encountered at the bottom of the foundation excavations should be removed to the level of suitable soils or properly compacted structural fill as directed by the Geotechnical Engineer.

After opening, foundation excavations should be observed and concrete placed as quickly as possible to avoid exposure of the excavation bottoms to wetting and drying. Surface run-off water should be drained away from the excavations and not be allowed to pond. If possible, the foundation concrete should be placed during the same day the excavation is made. If the soils will be exposed for more than 2 days, consideration should be given to placing a thin layer of rock atop the exposed subgrade to protect it from the elements.

Based on the known subsurface conditions and site geology, laboratory testing and past experience, we anticipate that properly designed and constructed foundations supported on the recommended materials should not exceed maximum total and differential settlements of 1-inch and ½-inch between 25-foot column spans, respectively.

3.5 Floor Slab Recommendations

Given the presence of existing, variable strength fill soils, there is some risk of future floor slab settlement if the floor slabs are supported on the existing fill in its existing condition. To completely mitigate the settlement risk, the fill soils would be removed and replaced with properly compacted structural fill. However, given the thickness of the existing fill soils, that approach may not be economical. A more limited approach would be to partially overexcavate the existing fill soil at least 12 inches, recompact the exposed fill surface, and then replace with well-graded crushed rock gravel structural fill (subbase). Partial overexcavation carries a little more risk, but it’s our opinion that risk is relatively low and would primarily result in some settlement cracking of slabs.

For the purposes of this report, we have assumed that maximum floor slab loads will not exceed 150 psf. Based on the existing soil conditions, the design of slabs-on-grade can be based on a subgrade modulus (k) of 125 pci. This subgrade modulus value represents an anticipated value which would be obtained in a standard in-situ plate test with a 1-foot square plate. Use of this subgrade modulus for design or other on-grade structural elements should include appropriate modification based on dimensions as necessary.

Concrete floor slabs-on-grade should be supported on a base course consisting of at least 6 inches of properly compacted, crushed rock gravel structural fill. The floor slabs should have an adequate number of joints to reduce cracking resulting from any differential movement and shrinkage.

Prior to placing the structural fill, the exposed subgrade surface should be prepared as discussed in Section 3.2 the subgrade will need to be visually evaluated by a representative of the Geotechnical Engineer by soil probing. If fill is required, the structural fill should be placed on the prepared subgrade after it has been approved by the Geotechnical Engineer.

The 6-inch thick crushed rock structural fill should provide a capillary break to limit migration of moisture through the slab. If additional protection against moisture vapor is desired, a moisture vapor retarding membrane may also be incorporated into the design. Factors such as cost, special considerations for construction, and the floor coverings suggest that decisions on the use of vapor retarding membranes be made by the project design team, the contractor and the owner.

3.6 Retaining Wall Recommendations

We are not aware of any retaining walls being planned for the project. As such, we are providing general retaining wall recommendations for preliminary use and should be provided retaining wall design specifics once they are known.

Retaining wall footings should be designed in general accordance with the recommendations contained in Section 3.4 above. Lateral earth pressures on walls, which are not restrained at the top, may be calculated on the basis of an "active" equivalent fluid pressure of 40 pcf for level backfill, and 65 pcf for sloping backfill with a maximum 2H:1V slope. Lateral earth pressures on walls that are restrained from yielding at the top may be calculated on the basis of an "at-rest" equivalent fluid pressure of 60 pcf for level backfill, and 95 pcf for sloping backfill with a maximum 2H:1V slope. The stated equivalent fluid pressures do not include surcharge loads, such as foundation, vehicle, equipment, etc., adjacent to walls, hydrostatic pressure buildup, or earthquake loading.

Lateral frictional resistance between the base of footings and the subgrade can be expressed as the applied vertical load multiplied by a coefficient of friction of 0.32 for concrete foundations bearing directly on native fine-grained soils or 0.42 for concrete foundations bearing on at least 12 inches of granular structural fill. In addition, lateral loads may be resisted by passive earth pressures based on an equivalent fluid density of 300 pounds per cubic foot (pcf) for footings poured "neat" against in-situ soils, or properly backfilled with structural fill. These are ultimate values - we recommend a factor of safety of 1.5 be applied to the equivalent fluid pressure, which is appropriate due to the amount of movement required to develop full passive resistance.

We recommend that retaining walls be designed for an earth pressure determined using the Mononobe-Okabe method to mitigate future seismic forces. Our calculations were based on one-half of the Design Peak Ground Acceleration (PGA) value of 0.278g, which was obtained from Table 2 above. For seismic loading on retaining walls with level backfill, new research indicates that the seismic load is to be applied at 1/3 H of the wall instead of 2/3 H, where H is the height of the wall[5]. We recommend that a Mononobe-Okabe earthquake thrust per linear foot of 7.5 psf * H^2 be applied at 1/3 H from the base of the wall, where H is the height of the wall measured in

---

[5] Lew, M., et al (2010). "Seismic Earth Pressures on Deep Building Basements," SEAOC 2010 Convention Proceedings, Indian Wells, CA.

feet. Note that the recommended earthquake thrust value is appropriate for slopes behind the retaining wall of up to 10 degrees.

All backfill for retaining walls should be select granular material, such as sand or crushed rock with a maximum particle size between ¾ and 1½ inches, having less than five percent material passing the No. 200 sieve. Because of the fines content, the soil on site **will not** meet this requirement, and it will be necessary to import specified material to the project for structural drainage backfill behind retaining walls. Silty soils can be used for the last 18 to 24 inches of backfill, thus acting as a seal to the granular backfill.

All backfill behind retaining walls should be moisture conditioned to within +/- 2 percent of optimum moisture content and compacted to a minimum of 90 percent of the material's maximum dry density as determined in accordance with ASTM D1557. This recommendation applies to all backfill located within a horizontal distance equal to 75 percent of the wall height, but should be no less than 4 feet.

An adequate subsurface drain system will need to be designed and installed behind retaining walls to prevent hydrostatic buildup. A waterproofing system should be designed to mitigate against moisture intrusion.

3.7 Pavement Recommendations

After pavement subgrades have been stripped, the exposed pavement subgrade soil should be proofrolled with a fully loaded dual axle dump truck before the placement of any imported granular fill base rock. Areas found to be soft or yielding under the weight of the dump truck should be overexcavated as recommended by an EEI representative and replaced with properly compacted granular structural fill. Given the presence of existing, variably compacted fill soils, we expect that there could be some overexcavation recommended during construction.

The recommended pavement section thicknesses presented below should be considered typical and minimum for the assumed traffic loading parameters and assumed California Bearing Ratio (CBR) value of 6 for fine-grained soils. Using the ASSHTO method of flexible pavement design, the following design parameters have been assumed:

- Pavement design life of 20 years.
- Terminal serviceability (P_t) of 2 (i.e. poor condition).
- A regional factor (R) of 3.0 (generally moderate weather conditions).
- 18,000-pound equivalent single axle load (ESAL) of 5 per day for parking and 20 ESALs per day for driveways.

The project Civil Engineer should review our assumptions to confirm they are appropriate for the anticipated traffic loading. Using the above assumptions, we recommend the following typical "standard" pavement section for the proposed development of the property. The tables below summarize our recommendations for asphaltic concrete and concrete pavement sections, and pervious concrete base course, respectively.

Table 4: Asphaltic Concrete Section Recommended Minimum Thicknesses

PAVEMENT MATERIAL	CAR PARKING	DRIVEWAY
Asphaltic Concrete (inches)	2.5	3
Crushed Aggregate Base Course (inches) underlain by Mirafi 500X or equivalent	7	9

Asphalt pavement base course material should consist of a well-graded 1½-inch or ¾-inch-minus crushed rock having less than 5 percent material passing the No. 200 sieve. The base course and asphaltic concrete materials should conform to the requirements set forth in the latest edition of the State of Oregon Standard Specifications for Highway Construction. Base course material should be moisture conditioned to within ± 2 percent of optimum moisture content, and compacted to a minimum of 95 percent of the material's maximum dry density as determined in accordance with ASTM D1557 (Modified Proctor). Fill materials should be placed in layers that, when compacted, do not exceed about 8 inches. Asphaltic concrete material should be compacted to at least 91 percent of the material's theoretical maximum density as determined in accordance ASTM D2041 (Rice Specific Gravity).

As requested, we are also providing a gravel section thickness for permeable pavement to support traffic loading. Our recommendations in Table 5 below do not include any strength contribution from the permeable pavement section (i.e. we are relying entirely on the gravel.

Table 5: Permeable Pavement Section Recommended Minimum Thicknesses

PAVEMENT MATERIAL	CAR PARKING	DRIVEWAY
Crushed Aggregate Base Course (inches) underlain by Mirafi 500X or equivalent	14	18

A representative of the Geotechnical Engineer should approve any selected granular fill material before importing it to the site. Each lift of compacted engineered fill should be evaluated by a representative of the Geotechnical Engineer prior to placement of subsequent lifts. The base course fill should extend horizontally outward beyond the exterior perimeter of the pavement at least three feet, prior to sloping.

In order to achieve the assumed 20-year design life, pavement does need regular maintenance to protect the underlying subgrade from being damaged. The primary concern is subgrade saturation which can cause it to weaken. Proper site drainage should be maintained to protect pavement areas. In addition, cracks that develop in the pavement should be sealed on a regular basis.

4.0 CONSTRUCTION CONSIDERATIONS

EEI should be retained to provide observation and testing of construction activities involved in the foundation, earthwork, and related activities of this project. EEI cannot accept any responsibility for any conditions that deviate from those described in this report, nor for the performance of the foundations if not engaged to also provide construction observation for this project.

4.1 Moisture Sensitive Soils/Weather Related Concerns

The soils encountered at this site are expected to be sensitive to disturbances caused by construction traffic and to changes in moisture content. During wet weather periods, increases in the moisture content of the soil can cause significant reduction in the soil strength and support capabilities. In addition, soils that become wet may be slow to dry and thus significantly retard the progress of grading and compaction activities. It will, therefore, be advantageous to perform earthwork and foundation construction activities during dry weather.

4.2 Drainage and Groundwater Considerations

Water should not be allowed to collect in the foundation excavations or on prepared subgrades for the slabs during construction. Positive site drainage should be maintained throughout construction activities. Undercut or excavated areas should be sloped toward one corner to facilitate removal of any collected rainwater, groundwater, or surface runoff.

The site grading plan should be developed to provide rapid drainage of surface water away from the building areas and to inhibit infiltration of surface water around the perimeter of the proposed structure. The grades should be sloped away from the construction area to prevent saturation of the foundation/slab subgrades which could lead to softening of the soils and excessive settlement.

4.3 Excavations

In Federal Register, Volume 54, No. 209 (October 1989), the United States Department of Labor, Occupational Safety and Health Administration (OSHA) amended its "Construction Standards for Excavations, 29 CFR, part 1926, Subpart P". This document and subsequent updates were issued to better insure the safety of workmen entering trenches or excavations. It is mandated by this federal regulation that excavations, whether they be utility trenches, basement excavations or footing excavations, be constructed in accordance with the new OSHA guidelines. It is our understanding that these regulations are being strictly enforced and if they are not closely followed, the owner and the contractor could be liable for substantial penalties.

The contractor is solely responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. The contractor's "responsible person", as defined in 29 CFR Part 1926, should evaluate the soil exposed in the excavations as part of the contractor's safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations.

We are providing this information solely as a service to our client. EEI does not assume responsibility for construction site safety or the contractor's compliance with local, state, and federal safety or other regulations.

5.0 REPORT LIMITATIONS

As is standard practice in the geotechnical industry, the conclusions contained in our report are considered preliminary because they are based on assumptions made about the soil, rock, and groundwater conditions exposed at the site during our subsurface investigation. A more complete extent of the actual subsurface conditions can only be identified when they are exposed during construction. Therefore, EEI should be retained as your consultant during construction to observe the actual conditions and to provide our final conclusions. If a different geotechnical consultant is retained to perform geotechnical inspection during construction then they should be relied upon to provide final design conclusions and recommendations, and should assume the role of geotechnical engineer of record.

The geotechnical recommendations presented in this report are based on the available project information, and the subsurface materials described in this report. If any of the noted information is incorrect, please inform EEI in writing so that we may amend the recommendations presented in this report if appropriate and if desired by the client. EEI will not be responsible for the implementation of its recommendations when it is not notified of changes in the project.

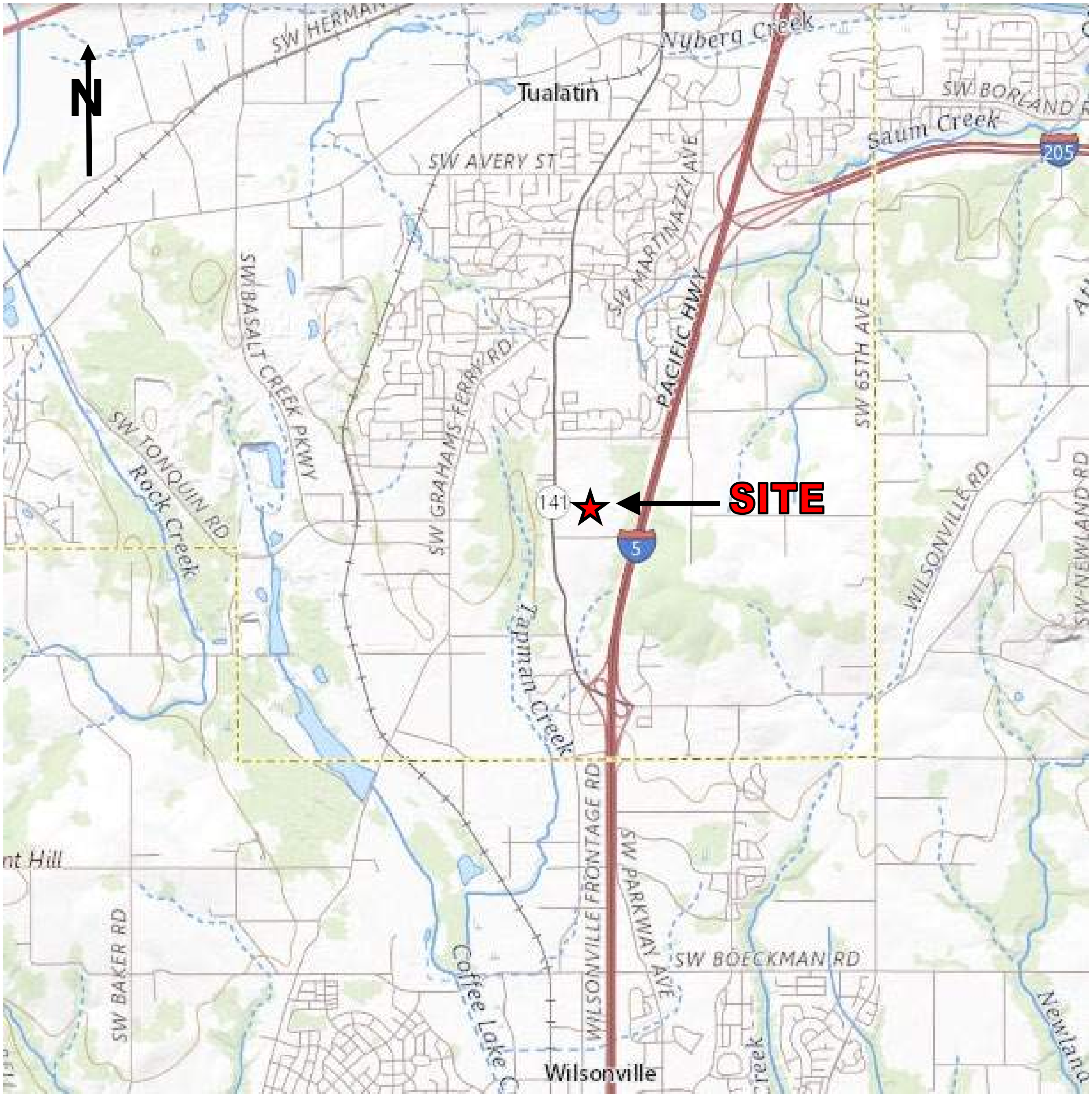
Once construction plans are finalized and a grading plan has been prepared, EEI should be retained to review those plans, and modify our existing recommendations related to the proposed construction, if determined to be necessary.

The Geotechnical Engineer warrants that the findings, recommendations, specifications, or professional advice contained herein have been made in accordance with generally accepted professional geotechnical engineering practices in the local area. No other warranties are implied or expressed.

This report has been prepared for the exclusive use of Community Partners for Affordable Housing for the specific application to the proposed Basalt Creek Affordable Housing development to be located at 23500 and 23550 Southwest Boones Ferry Road in Tualatin, Washington County, Oregon. EEI does not authorize the use of the advice herein nor the reliance upon the report by third parties without prior written authorization by EEI.

APPENDICES

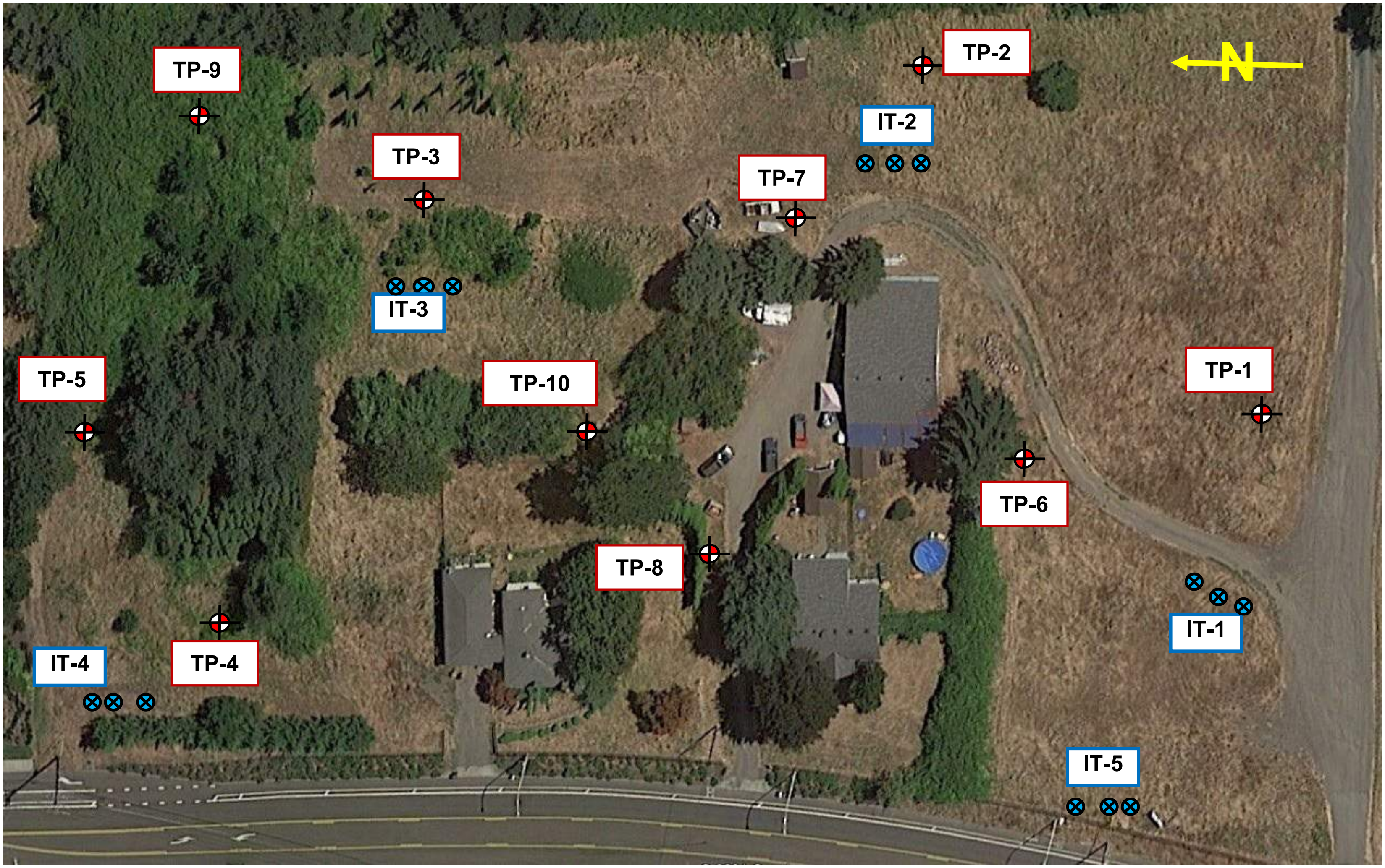
APPENDIX A – SITE LOCATION PLAN



Base map source: https://apps.nationalmap.gov/viewer/.

Earth Engineers, Inc.	**Proposed Basalt Creek Affordable Housing Project 23500 and 23550 Southwest Boones Ferry Road Tualatin, Washington County, Oregon**	**Report No. 21-023-1** **March 17, 2021**

APPENDIX B – EXPLORATION LOCATION PLAN



Base drawing source: “Preliminary” drawing A0.00 by Carlton Hart Architecture, undated.

Earth Engineers, Inc.	**Proposed Basalt Creek Affordable Housing Project** **23500 and 23550 Southwest Boones Ferry Road** **Tualatin, Washington County, Oregon**	**Report No.** **20-023-1**	**March 17, 2021**

Earth
Engineers,
Inc.

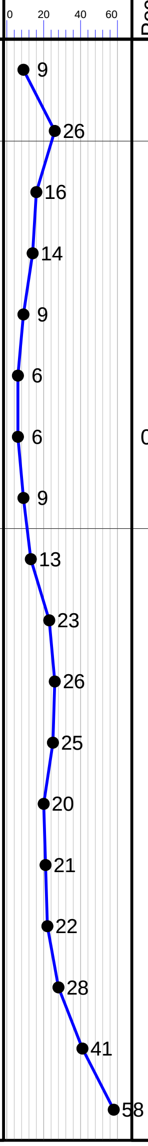
Appendix C: Test Pit TP-1

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 347
Date of Exploration: March 1, 2021

Depth (ft)	Water Level	Lithology Lithologic Symbol	Lithology Geologic Description of Soil and Rock Strata	Sampling Data Sample Number	Sampling Data Digging Effort	Sampling Data Drive Probe Blows Per 6 Inches	Sampling Data Pocket Pen. (tsf)	Sampling Data Moisture Content (%)	Sampling Data % Passing #200 Sieve	Sampling Data Liquid Limit	Sampling Data Plastic Limit	Sampling Data Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Easy							
			Silt (ML) - brown silt with orange and black mottling, very stiff to medium stiff, moist to wet									
				GRAB 1			3	24	89			
				GRAB 2			0.75	31	92	38	25	
4	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), stiff to hard, moist to wet									
				GRAB 3				29				
				GRAB 4	Hard			31				



Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 9 feet bgs. Groundwater seepage was encountered at depth of about 4 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

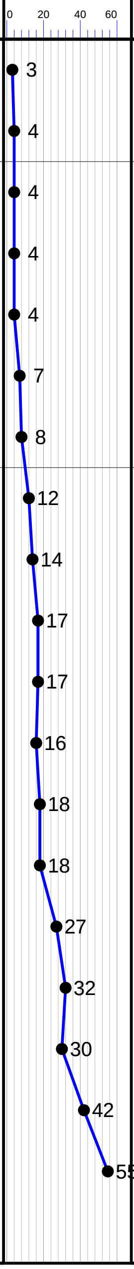
Earth Engineers, Inc.

Appendix C: Test Pit TP-2

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 353
Date of Exploration: March 1, 2021



		Lithology		Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with roots, and rootlets, moist		Easy	3						
						4						
1			Silt (ML) - brown silt with orange and black mottling, soft to medium stiff, moist	GRAB 1		4	0.75	31				
						4						
2						4						Hit a white PCV pipe
						7						
3						8						
	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), medium stiff to hard, moist to wet	GRAB 2		12	2.5	31				
4						14						
						17						
5						17						
						16						
6						18						
						18						
7						27						
				GRAB 3		32		49				
8						30						
					Hard	42						
9						55						
				GRAB 4				47				
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 10 feet bgs. Drive probe terminated at a depth of approximately 9.5 feet bgs. Groundwater seepage was encountered at depth of about 4 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

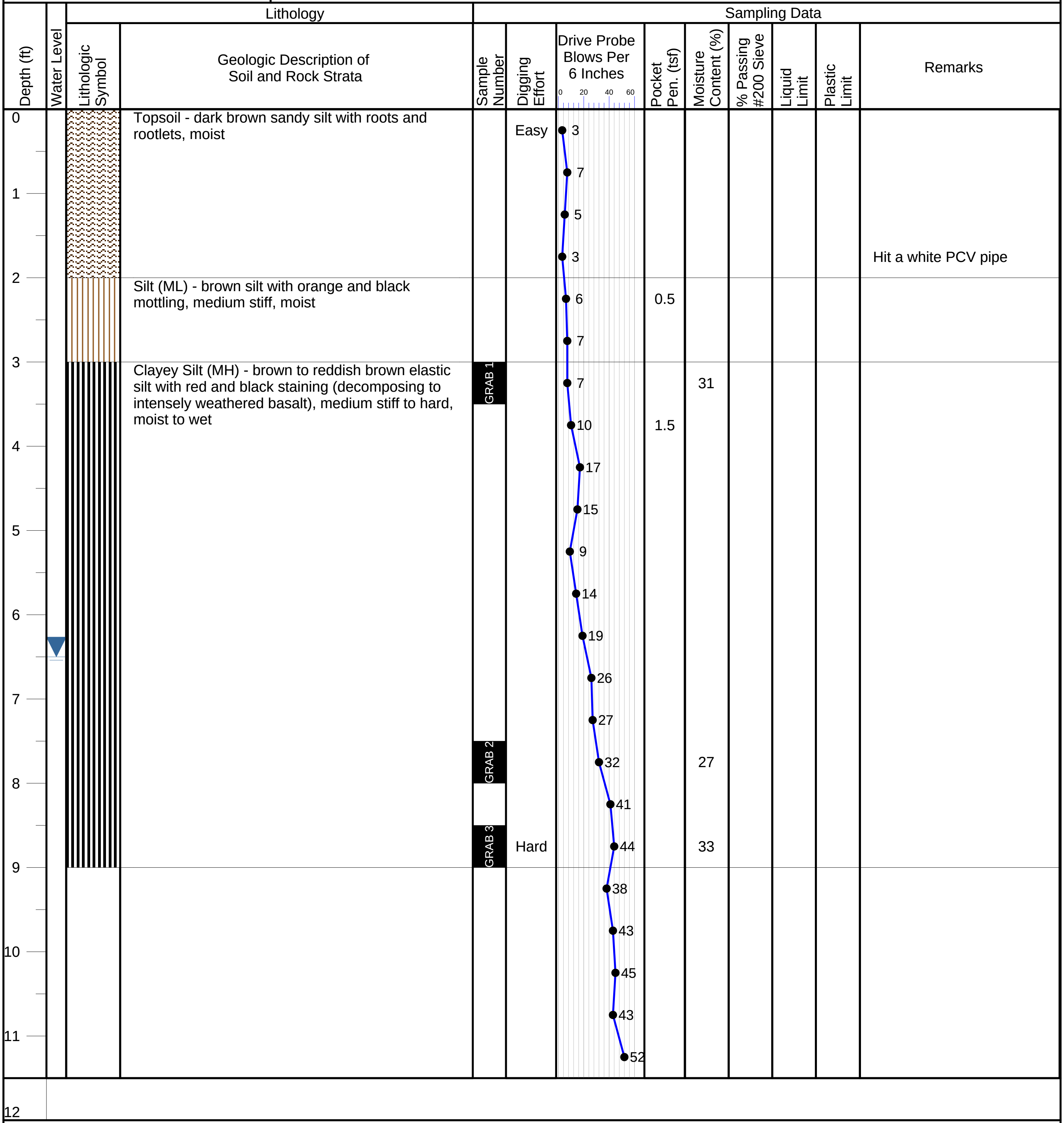
Earth Engineers, Inc.

Appendix C: Test Pit TP-3

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 354
Date of Exploration: March 1, 2021



Lithology				Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with roots and rootlets, moist		Easy	3 7 5 3						Hit a white PCV pipe
2			Silt (ML) - brown silt with orange and black mottling, medium stiff, moist			6 7	0.5					
3	▼		Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), medium stiff to hard, moist to wet	GRAB 1 GRAB 2 GRAB 3	Hard	7 10 17 15 9 14 19 26 27 32 41 44	1.5	31 27 33				
9						38 43 45 43 52						

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 11.5 feet bgs. Groundwater seepage was encountered at depth of about 6.5 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

Earth Engineers, Inc.

Appendix C: Test Pit TP-4

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 344
Date of Exploration: March 1, 2021

Depth (ft)	Water Level	Lithology Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sampling Data Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Easy	3						
						6						
1			Silt (ML) - brown silt, medium stiff, moist			7						
						6	1.25					
2						6						
						4						
3						8	1.25					
			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), stiff to hard, moist to wet	GRAB 1		12		31				
4						15						
						18						
5						22						
	▼					25						
6						22						
			Basalt - gray, moderately weathered, hard, moist	GRAB 2	Hard	24		27				
7												
8												
9												
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 7 feet bgs due to practical digging refusal. Drive probe terminated at a depth of approximately 7 feet bgs due to refusal. Groundwater seepage was encountered at depth of about 6 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

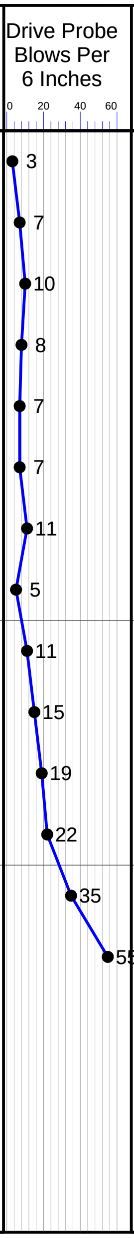
Earth Engineers, Inc.

Appendix C: Test Pit TP-5

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 346
Date of Exploration: March 1, 2021



Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0		▨	Fill - brown to dark brown silt with roots, rootlets, asphalt chunks, and rocks, moist		Easy	3						
1						7 10						
2						8 7						
3				GRAB 1		7	0.75	23	69			
						11 5						
4		▥	Silt (ML) - brown silt with some black mottling, stiff to very stiff, moist	GRAB 2		11	2	29	90			
5						15 19 22						
6	▼	▥	Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), very stiff to hard, moist to wet			35						
7					Hard	55						
8												
9				GRAB 3				44				
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 7 feet bgs due to refusal. Groundwater seepage was encountered at depth of about 6 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/1/2021. Approximate elevation based on Google Earth.

Earth Engineers, Inc.

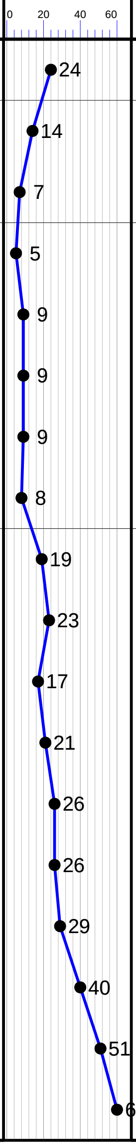
Appendix C: Test Pit TP-6

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 348
Date of Exploration: March 2, 2021

		Lithology		Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Mod.	24						
			Fill - dark borwn silt with gravel and some charcoal and brick fragments, moist			14						
1				GRAB 1		7	2.25	26				
			Silt (ML) - brown silt with orange and black mottling, medium stiff to stiff, moist to wet		Easy	5						
2						9						
						9						
3				GRAB 2		9	1.25	24				
						8						
4			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), very stiff to hard, moist to wet			19						
						23						
5				GRAB 3		17		26				
						21						
6						26						
						26						
7	▼					29						
						40						
8						51						
				GRAB 4	Hard	60		28				
9												



9
10
11
12

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 9 feet bgs. Groundwater seepage was encountered at depth of about 7.5 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

Earth
Engineers,
Inc.

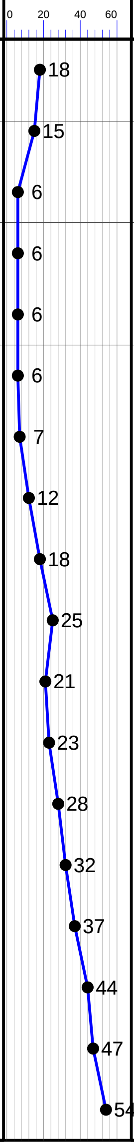
Appendix C: Test Pit TP-7

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 352
Date of Exploration: March 2, 2021

Depth (ft)	Water Level	Lithology Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sampling Data Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil - dark brown sandy silt with gravel, roots, and rootlets, moist		Mod.	18						
			Fill - dark borwn silt with gravel and some charcoal and brick fragments			15						
1				GRAB 1		6	0.5	25				
			Silt (ML) - brown silt with orange and black mottling, medium stiff, moist		Easy	6						
2						6						
			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), medium stiff to hard, moist to wet	GRAB 2		6	1.5	28	92	54	23	
3						7						
						12	2					
4	▼			GRAB 3		18		29				
						25						
5						21						
						23						
6						28						
						32						
7						37						
						44						
8						47						
				GRAB 4	Hard	54		31				
9												
10												
11												
12												



Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe terminated at a depth of approximately 9 feet bgs. Groundwater seepage was encountered at depth of about 4.5 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

Earth Engineers, Inc.

Appendix C: Test Pit TP-8

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 348
Date of Exploration: March 2, 2021

Lithology				Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches 0 20 40 60	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil- dark brown sandy silt with roots and rootlets, moist		Mod.							
1			Fill - brown clayey silt with gravel, charcoal, and bricks, moist	GRAB 1			2	24				Hit a steel water line
3			Silt (ML) - brown silt, very stiff to medium stiff to very stiff, moist to wet	GRAB 2	Easy		0.5	26				
6			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), very stiff to hard, moist	GRAB 3				28				
				GRAB 4	Hard			28				
9												
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe testing not attempted at this location. Groundwater was not encountered at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

Earth
Engineers,
Inc.

Appendix C: Test Pit TP-9

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 354
Date of Exploration: March 2, 2021

Depth (ft)	Water Level	Lithology: Lithologic Symbol	Lithology: Geologic Description of Soil and Rock Strata	Sampling Data: Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches 0 20 40 60	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Fill - brown to dark brown silt with roots, rootlets, charcoal, and rocks, moist									
1					Easy							
2							1					
3				GRAB 1				24				
4												
5												
6												
			Silt (ML) - brown silt, medium stiff to stiff, moist									Becomes Stiff
7				GRAB 2				26				
			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing basalt), stiff									
8												
9				GRAB 3				28				
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9.5 feet bgs. Drive probe testing not attempted at this location. Groundwater was not encountered at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

Earth Engineers, Inc.

Appendix C: Test Pit TP-10

Sheet 1 of 1

Client: Community Partners for Affordable Housing
Project: Basalt Creek Affordable Housing Project
Site Address: 23500 & 23550 SW Boones Ferry Road
Tualatin, Oregon
Location of Exploration: See Appendix B
Logged By: Anita Bauer

Report Number: 21-023-1
Excavation Contractor: Dan Fischer Excavating
Excavation Method: Excavator with 2 foot toothed bucket
Excavation Equipment: Hitachi Zaxis 40U
Approximate Ground Surface Elevation (ft msl): 349
Date of Exploration: March 2, 2021

		Lithology		Sampling Data								
Depth (ft)	Water Level	Lithologic Symbol	Geologic Description of Soil and Rock Strata	Sample Number	Digging Effort	Drive Probe Blows Per 6 Inches 0 20 40 60	Pocket Pen. (tsf)	Moisture Content (%)	% Passing #200 Sieve	Liquid Limit	Plastic Limit	Remarks
0			Topsoil- dark brown sandy silt with roots and rootlets, moist		Mod.							
				GRAB 1				30				
1			Fill - brown to reddish brown silt with bricks and charcoal, moist									
2				GRAB 2			1	28				
3												
			Clayey Silt (MH) - brown to reddish brown elastic silt with red and black staining (decomposing to intensely weathered basalt), stiff to hard, moist to wet	GRAB 3			2	30	94			
4												
5												
6	▼			GRAB 4				28				
7												
8												
9				GRAB 5	Hard			27				
10												
11												
12												

Notes: Test pit terminated at a depth of approximately 9 feet bgs. Drive probe testing not attempted at this location. Groundwater seepage was encountered at a depth of about 6 feet bgs at the time of our exploration. Test pit loosely backfilled with excavated soil on 3/2/2021. Approximate elevation based on Google Earth.

APPENDIX D: SOIL CLASSIFICATION LEGEND

APPARENT CONSISTENCY OF COHESIVE SOILS (PECK, HANSON & THORNBURN 1974, AASHTO 1988)

Descriptor	SPT N_{60} (blows/foot)*	Pocket Penetrometer, Qp (tsf)	Torvane (tsf)	Field Approximation
Very Soft	< 2	< 0.25	< 0.12	Easily penetrated several inches by fist
Soft	2 – 4	0.25 – 0.50	0.12 – 0.25	Easily penetrated several inches by thumb
Medium Stiff	5 – 8	0.50 – 1.0	0.25 – 0.50	Penetrated several inches by thumb w/moderate effort
Stiff	9 – 15	1.0 – 2.0	0.50 – 1.0	Readily indented by thumbnail
Very Stiff	16 – 30	2.0 – 4.0	1.0 – 2.0	Indented by thumb but penetrated only with great effort
Hard	> 30	> 4.0	> 2.0	Indented by thumbnail with difficulty

* Using SPT N_{60} is considered a crude approximation for cohesive soils.

APPARENT DENSITY OF COHESIONLESS SOILS (AASHTO 1988)

Descriptor	SPT N_{60} Value (blows/foot)
Very Loose	0 – 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	> 50

MOISTURE
(ASTM D2488-06)

Descriptor	Criteria
Dry	Absence of moisture, dusty, dry to the touch, well below optimum moisture content (per ASTM D698 or D1557)
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table, well above optimum moisture content (per ASTM D698 or D1557)

PERCENT OR PROPORTION OF SOILS
(ASTM D2488-06)

Descriptor	Criteria
Trace	Particles are present but estimated < 5%
Few	5 – 10%
Little	15 – 25%
Some	30 – 45%
Mostly	50 – 100%

Percentages are estimated to nearest 5% in the field. Use “about” unless percentages are based on laboratory testing.

SOIL PARTICLE SIZE
(ASTM D2488-06)

Descriptor	Size
Boulder	> 12 inches
Cobble	3 to 12 inches
Gravel - Coarse Fine	¾ inch to 3 inches No. 4 sieve to ¾ inch
Sand - Coarse Medium Fine	No. 10 to No. 4 sieve (4.75mm) No. 40 to No. 10 sieve (2mm) No. 200 to No. 40 sieve (.425mm)
Silt and Clay (“fines”)	Passing No. 200 sieve (0.075mm)

UNIFIED SOIL CLASSIFICATION SYSTEM (ASTM D2488)

Major Division			Group Symbol	Description
Coarse Grained Soils (more than 50% retained on #200 sieve)	**Gravel** (50% or more retained on No. 4 sieve)	Clean Gravel	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		Gravel with fines	GM	Silty gravels and gravel-sand-silt mixtures
			GC	Clayey gravels and gravel-sand-clay mixtures
	Sand (> 50% passing No. 4 sieve)	Clean sand	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly-graded sands and gravelly sands, little or no fines
		Sand with fines	SM	Silty sands and sand-silt mixtures
			SC	Clayey sands and sand-clay mixtures
Fine Grained Soils (50% or more passing #200 sieve)	**Silt and Clay** (liquid limit < 50)		ML	Inorganic silts, rock flour and clayey silts
			CL	Inorganic clays of low-medium plasticity, gravelly, sandy & lean clays
			OL	Organic silts and organic silty clays of low plasticity
	Silt and Clay (liquid limit > 50)		MH	Inorganic silts and clayey silts
			CH	Inorganic clays or high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
Highly Organic Soils			PT	Peat, muck and other highly organic soils

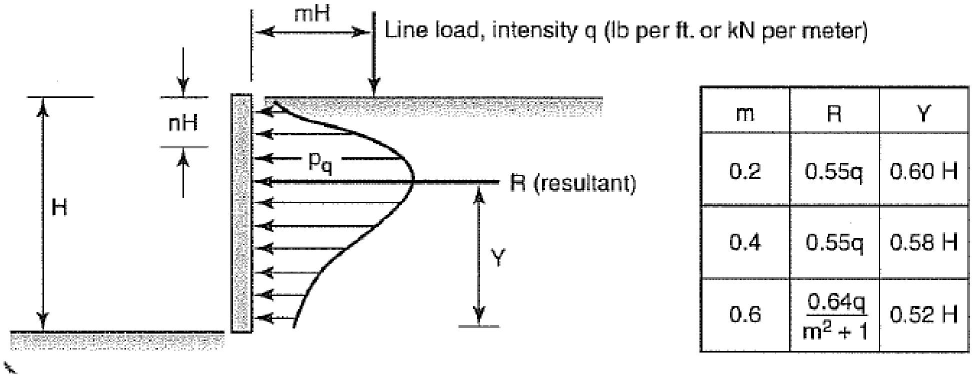
Earth
Engineers,
Inc.

GRAPHIC SYMBOL LEGEND

GRAB	☒	Grab sample
SPT	■	Standard Penetration Test (2” OD), ASTM D1586
ST	▨	Shelby Tube, ASTM D1587 (pushed)
DM	▤	Dames and Moore ring sampler (3.25” OD and 140-pound hammer)
CORE	▥	Rock coring

APPENDIX E: SURCHARGE-INDUCED LATERAL EARTH PRESSURES FOR WALL DESIGN

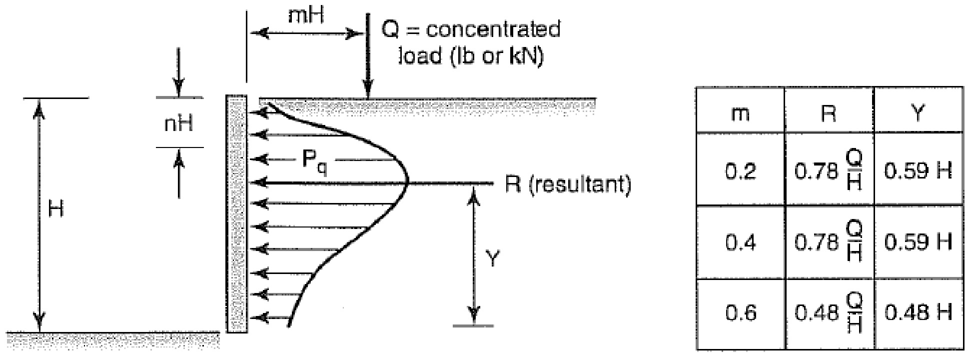
LINE LOAD (applicable for retaining walls not exceeding 20 feet in height):



m	R	Y
0.2	0.55q	0.60 H
0.4	0.55q	0.58 H
0.6	$\frac{0.64q}{m^2+1}$	0.52 H

Figure 16-28 Pressure distribution against vertical wall resulting from line load of intensity *q*.

CONCENTRATED POINT LOAD (applicable for retaining walls not exceeding 20 feet in height):



m	R	Y
0.2	$0.78\frac{Q}{H}$	0.59 H
0.4	$0.78\frac{Q}{H}$	0.59 H
0.6	$0.48\frac{Q}{H}$	0.48 H

Figure 16-27 Pressure distribution against vertical wall resulting from point load, *Q*.

AREAL LOAD:

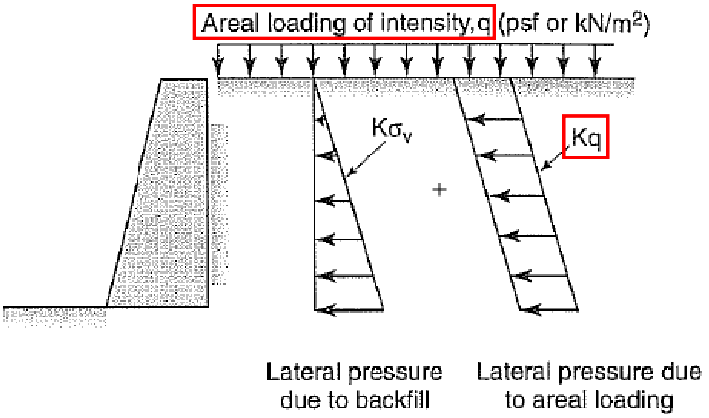
Figure 16-26 Influence of areal loading on wall pressures.

use K=0.4 for active condition (i.e. top of wall allowed to deflect laterally)

use K=0.9 for at-rest condition (i.e. top of wall not allowed to deflect laterally)

Resultant, R = K * q * H

Where H = wall height (feet)



Source of Figures: McCarthy, D.F., 1998, "Essentials of Soil Mechanics and foundations, Basic Geotechnics, Fifth Edition."

Earth Engineers, Inc.

Proposed Basalt Creek Affordable Housing Project
23500 and 23550 Southwest Boones Ferry Road
Tualatin, Washington County, Oregon

Report No. 21-023-1

March 17, 2021

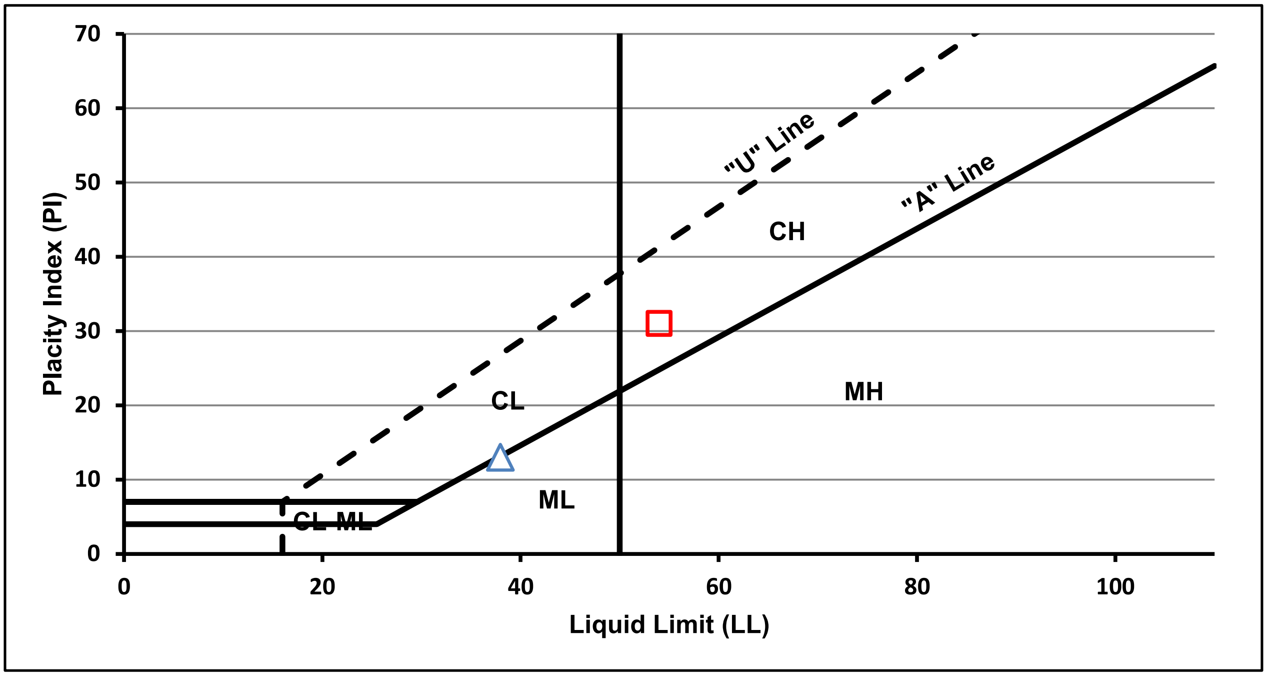
Earth
Engineers,
Inc.

APPENDIX F: LAB TEST RESULTS
REPORT OF ATTERBERG LIMITS
ASTM D 4318

TESTED FOR:	Community Partners for Affordable Housing P.O. Box 23206 Tigard, Oregon 97239 Attention: Jilian Saurage Felton	PROJECT:	Basalt Creek Affordable Housing 23500 and 23550 Southwest Boones Ferry Road Tualatin, Washington County, OR

DATE: 3/12/2021 REPORT NO.: 21-023-1

TEST DATA



Location	Depth (feet)	Description (USCS)	Moisture Content, %	% Passing #200 Sieve	Atterberg Limits		
					LL	PL	PI
△ TP-1	3	Silt (ML)	31	92	38	25	13
□ TP-7	2.5	Elastic Silt (MH)	28	92	54	23	31

Remarks:
Lab Technician: Anita B.

USCS Classification per ASTM D 2487
Moisture Content per ASTM D 2216
Percent Passing #200 Sieve per ASTM D 1140
Atterberg Limits per ASTM D 4318

Respectfully Submitted,
Earth Engineers, Inc.

Troy Hull, P.E., G.E.