

Stormwater Report & Calculations For:

Proposed Starbucks & Panda Express Development

Massillon, Ohio

Excel Job #2178020

January 20, 2023

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0.0 Introduction

0.1 Existing Conditions

The proposed development project is located directly south of Lincoln Way E and centrally between the intersections of Lincoln Way E and 24th/25th streets in the City of Massillon, Ohio. The 2.27-acre project site is bound by Lincoln Way E to the north and is surrounded on all other sides by adjacent residential properties. The existing site is currently vacant/open land consisting of maintained lawn cover. It appears that residential homes may have historically existed on the subject site, but recent aerial photography indicates a consistent use of vacant/open land. The site currently drains overland from north to south with approximately 15 feet of elevation drop occurring from the northern extent of the site to the southern-most portion of the site. Regionally, the general area continues to topographically slope in the southwest direction and is located within the overall watershed of the Tuscarawas River. Reference Appendix A for a representation of the existing site and current drainage patterns.

0.2 Proposed Project Overview

The proposed development project involves construction of a new Panda Express quick-serve restaurant and Starbucks coffeehouse with associated site improvements. Site improvements include new paved parking areas, concrete drive-thru lanes, internal sidewalk networks, and new refuse enclosures. The project will result in approximately 2.37 acres of disturbed site area, which includes off-site utility trenching areas. Stormwater from the proposed development will be conveyed via onsite inlets and storm sewer network to a proposed underground detention system that will serve to meet the water quality and quantity requirements set forth by state and local requirements. The underground stormwater detention system will discharge via a new storm sewer connection to the City of Massillon storm sewer network located within 25th street. This system drains south and discharges southeast of McDonald Cir SE which is consistent with the existing overland drainage route. Reference Appendix B for a representation of the post-development site drainage patterns.

0.3 Stormwater Management Applicability

The proposed development project will disturb approximately 2.37 acres of land and is therefore subject to implementation of post-construction stormwater management controls on the subject site. The subject site will be required to meet the stormwater management water quality standards set forth by Stark County and Ohio EPA. Additionally, the site will be required to meet the stormwater post-development peak discharge standards set forth by the City of Massillon. The below sections of this report detail how the proposed project meets or exceeds the applicable state and local stormwater management requirements.

1.0 Design Criteria

1.1 Soils

Soil characteristics for the site were determined by utilizing available Web Soil Survey information. See Table 1 below for a summary of the web soil survey results and reference Appendix D for the associated web soil survey map. Based on these results, a curve number of 74 has been designated for site open space areas consistent with hydrologic group C soils. Site-specific geotechnical investigations have not yet been completed on the project site.

Table 1: Web Soil Survey

MAP SYMBOL	SOIL TYPE	HYDROLOGIC RATING
CeB	Canfield-Urban Land Complex, 2 to 6 percent slopes	C/D

1.2 Rainfall Data

NOAA Atlas 14, City of Massillon rainfall depths with a type II distribution were used for the site stormwater calculations. Reference Table 2 below for the site specific rainfall depths. Additional rainfall data is provided in Appendix G

Table 2: NOAA Atlas 14 24-hour Rainfall Depth

DESIGN STORM	RAINFALL DEPTH (INCHES)
2-YEAR	2.44
5-YEAR	3.04
10-YEAR	3.56
25-YEAR	4.33
50-YEAR	5.00
100-YEAR	5.73

2.0 Stormwater Management Requirements

2.1 Stormwater Quantity/Runoff Rate Control

City of Massillon- The post-developed rate of runoff is not permitted to exceed the pre-developed rate of runoff. The proposed development will be required to maintain or reduce the 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, and 100-yr, 24-hour post development peak runoff discharge rates to the respective pre-development peak runoff discharge rates.

Stormwater from the post-development site will drain via a new onsite storm sewer network to a proposed underground stormwater detention system that will serve to reduce post-development peak flows to the pre-development conditions prior to discharging to the City of Massillon public storm sewer system. The underground detention system will consist of perforated 84" CMP pipe along with associated aggregate bedding and cover material. The voids within the aggregate will also act as temporary stormwater storage for the system. The system will discharge through an outlet control structure consisting of a storm manhole with an internal weir plate. The internal weir plate will have multiple orifice openings at varying elevations to control post-development peak flow rates to the pre-development conditions. Reference the construction plan set for specific orifice sizes and elevations used in the structure. Refer to Table 3 below for a summary of the post-development peak runoff rates in comparison to the pre-development rates. As shown in the table below, post-development rates are reduced to less than pre-development conditions for all storm events. Reference detailed HydroCAD calculations provided in Appendix C.

Table 3: Detailed Runoff Summary

	PRE-DEVELOPMENT	POST-DEVELOPMENT			
DESIGN STORM	Total Pre-Development Peak Discharge (cfs)	To Underground Detention (cfs)	Underground Detention Release Rate (cfs)	Undetained (cfs)	Total Post Development (Combined Underground Detention Release & Undetained) (cfs)
2 YR-24 HR	1.30	5.09	0.98	0.13	1.00
5 YR-24 HR	2.24	6.59	2.15	0.17	2.19
10 YR-24 HR	3.13	7.89	2.81	0.20	2.88
25 YR-24 HR	4.56	9.80	3.87	0.24	3.96
50 YR-24 HR	5.88	11.45	5.56	0.28	5.69
100 YR-24HR	7.36	13.24	6.53	0.32	6.68

Table 4: Total Peak Discharge Release Summary

DESIGN STORM	PREDEVELOPMENT (CFS)	POST DEVELOPMENT (CFS)
2 YR- 24 HR	1.30	1.00
5 YR- 24 HR	2.24	2.19
10 YR- 24 HR	3.13	2.88
25 YR- 24 HR	4.56	3.96
50 YR- 24 HR	5.88	5.69
100 YR- 24 HR	7.36	6.68

Therefore, peak discharge requirements are met.

2.2 Stormwater Quality/WQv

Stark County/OH EPA- The subject development will be held to the water quality requirements set forth by Stark County Soil and Water district. The development will need to provide treatment of the water quality volume which is derived from a 0.90 inch rainfall event. This results in a total water quality volume of 4,420 cu-ft (0.10 ac-ft) for the subject site. This volume must be detained and released over a period of not less than 24 hours. Additionally, no more than half of the volume can be released in the first 1/3 of the drawdown time. The underground detention system proposed on the subject site will provide the required water quality volume. The water quality volume will be release through a 1.3" orifice located in an outlet control structure. Reference Appendix E for water quality volume calculations.

Therefore, water quality volume requirements have been met.

2.3 Stormwater Quality/WQf

Stark County/OH EPA- Since the subject development will be utilizing an underground detention system to meet site stormwater requirements, pretreatment of the site stormwater is required up to the water quality flow rate. The development WQf is 3.27 cfs. A hydrodynamic separator (Contech Cascade Separator) is proposed on the project site. Based on the WQf, a CS-6 unit is required. See Appendix E for WQf calculations.

Therefore, water quality flow requirements have been met.

3.0 Storm Sewer Design

All storm sewer has been designed to convey the 100-year post development storm based on rational method calculations. See Appendix F for pipe drainage areas and pipe sizing calculations.

3.1 Emergency Overflow Route

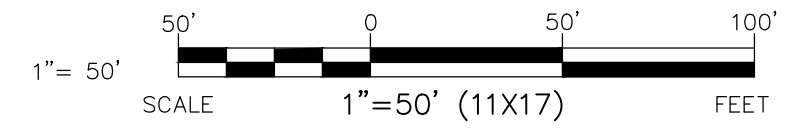
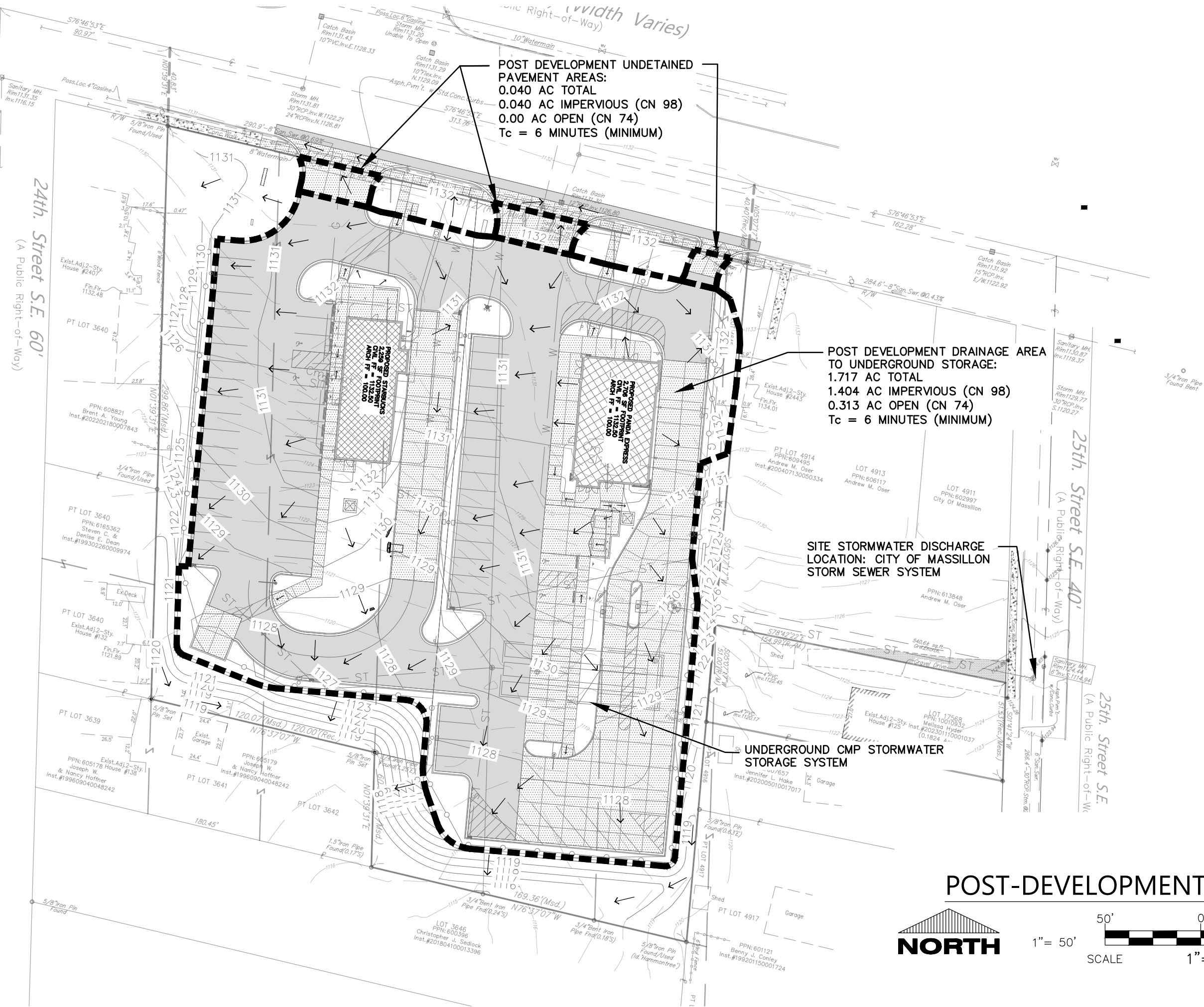
The emergency overflow route for any events exceeding the 100-year storm event is to the south of the site to match the current site conditions.

4.0 Erosion Control

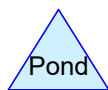
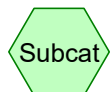
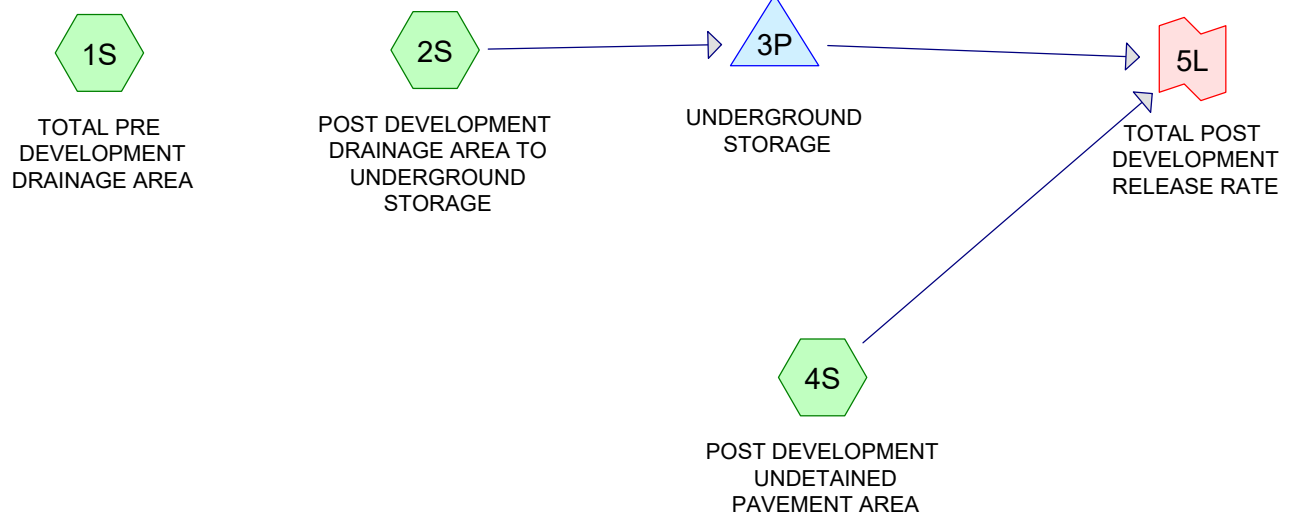
The erosion control specifications, construction sequence, site stabilization notes, seeding notes, dewatering notes, and post construction and maintenance plan will be included on sheet C0.1 and C1.2 of the construction plan set.

Appendix A: Pre-Development Basin Area(s)

Appendix B: Post Development Basin Area(s)



Appendix C: Peak Discharge Calculations



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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.757	74	Existing Lawn Area (1S)
1.444	98	Impervious (2S, 4S)
0.313	74	Open (2S)
3.514	84	TOTAL AREA

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: TOTAL PRE

Runoff Area=1.757 ac 0.00% Impervious Runoff Depth>0.57"
Flow Length=310' Tc=12.1 min CN=74 Runoff=1.30 cfs 0.084 af

Subcatchment2S: POST DEVELOPMENT

Runoff Area=1.717 ac 81.77% Impervious Runoff Depth>1.81"
Tc=6.0 min CN=94 Runoff=5.09 cfs 0.259 af

Subcatchment4S: POST DEVELOPMENT

Runoff Area=0.040 ac 100.00% Impervious Runoff Depth>2.21"
Tc=6.0 min CN=98 Runoff=0.13 cfs 0.007 af

Pond 3P: UNDERGROUND STORAGE

Peak Elev=1,121.58' Storage=0.134 af Inflow=5.09 cfs 0.259 af
Outflow=0.98 cfs 0.160 af

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow=1.00 cfs 0.167 af
Primary=1.00 cfs 0.167 af

Total Runoff Area = 3.514 ac Runoff Volume = 0.350 af Average Runoff Depth = 1.20"
58.91% Pervious = 2.070 ac 41.09% Impervious = 1.444 ac

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Type II 24-hr 2 YR Rainfall=2.44"

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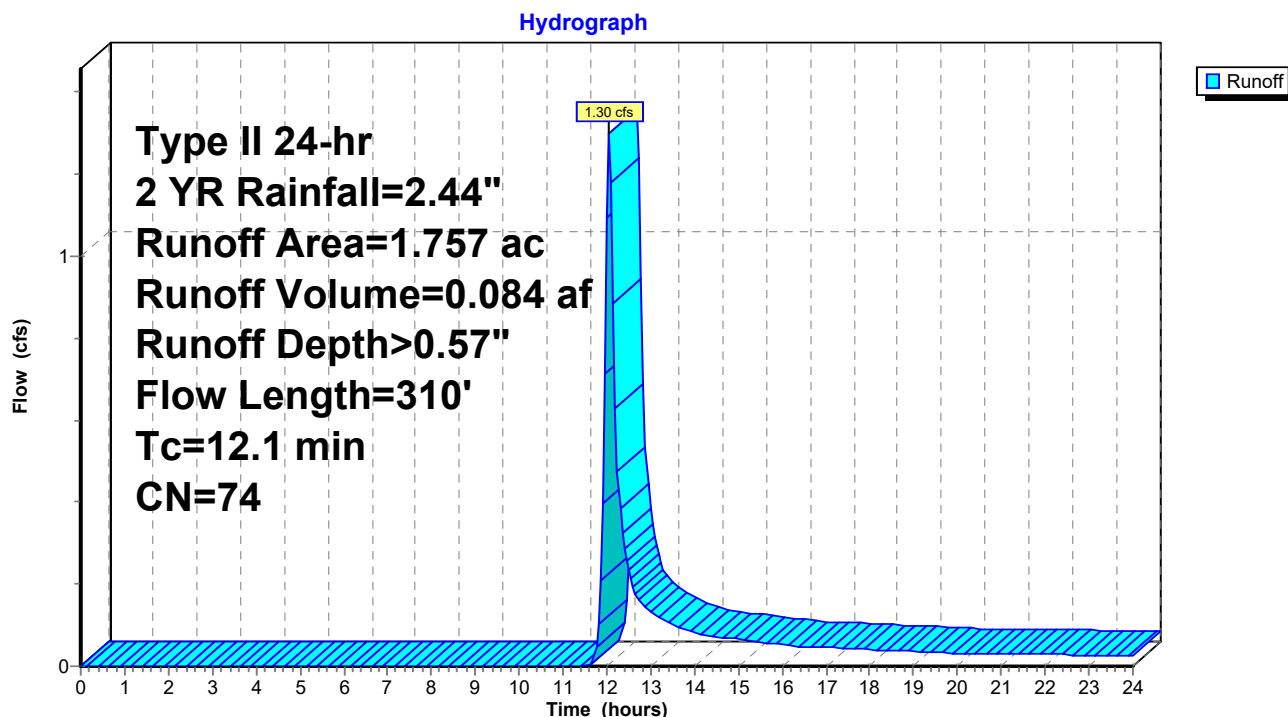
Summary for Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

Runoff = 1.30 cfs @ 12.06 hrs, Volume= 0.084 af, Depth> 0.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 2 YR Rainfall=2.44"

Area (ac)	CN	Description
* 1.757	74	Existing Lawn Area
1.757		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	100	0.0200	0.15		Sheet Flow, Sheet Flow Grass: Short n= 0.150 P2= 2.44"
0.3	95	0.1100	5.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
0.6	115	0.0430	3.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
12.1	310	Total			

Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

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Type II 24-hr 2 YR Rainfall=2.44"

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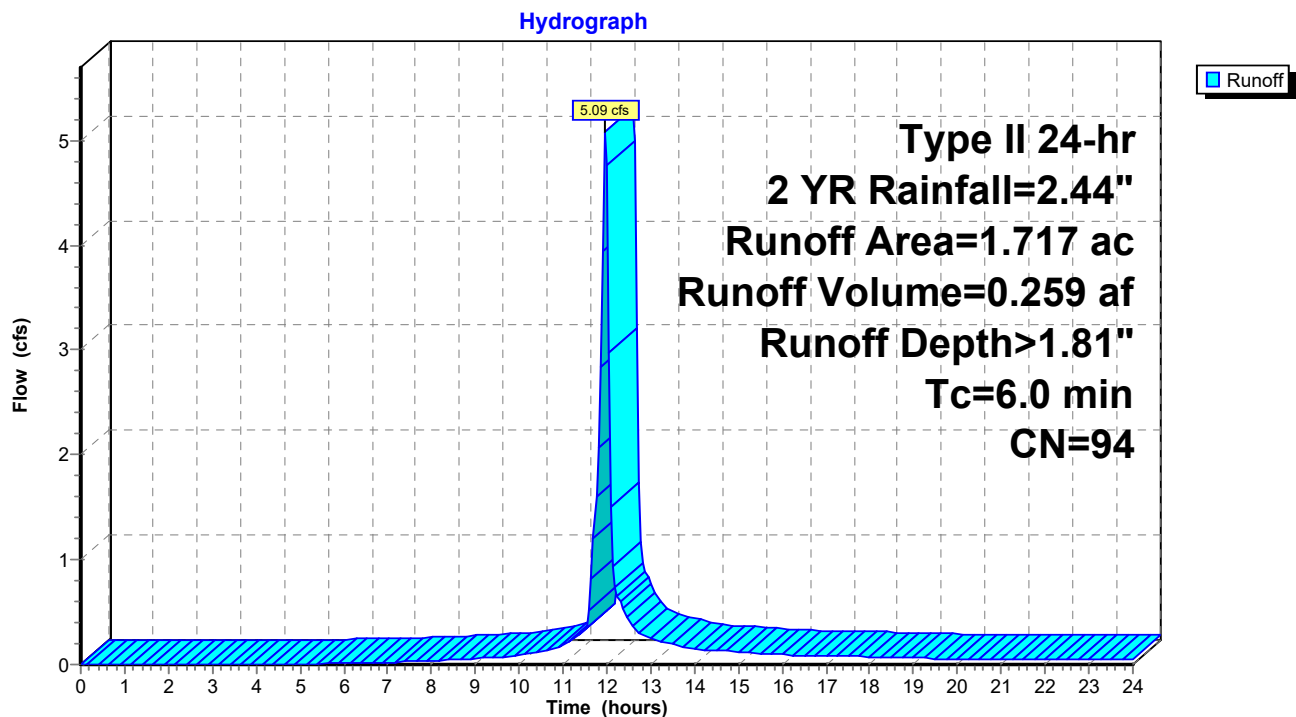
Summary for Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

Runoff = 5.09 cfs @ 11.97 hrs, Volume= 0.259 af, Depth> 1.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 2 YR Rainfall=2.44"

Area (ac)	CN	Description
* 1.404	98	Impervious
* 0.313	74	Open
1.717	94	Weighted Average
0.313		18.23% Pervious Area
1.404		81.77% Impervious Area

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

Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

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Type II 24-hr 2 YR Rainfall=2.44"

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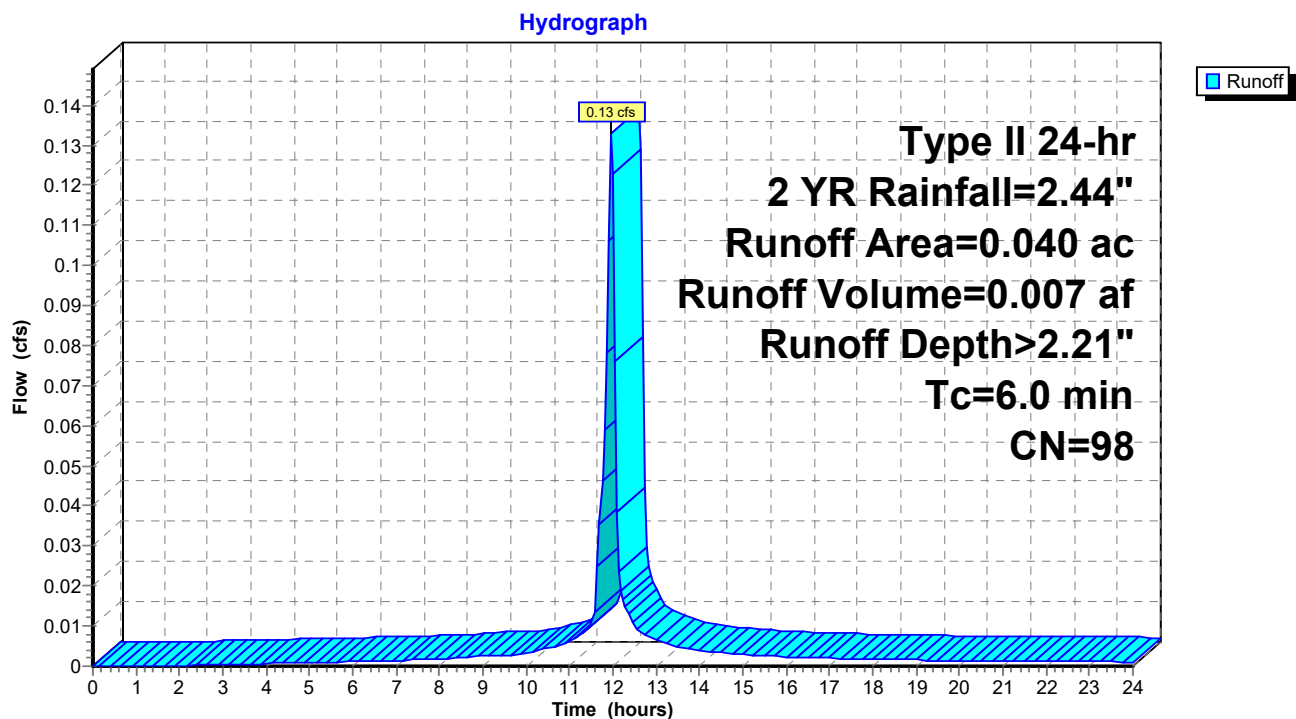
Summary for Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Runoff = 0.13 cfs @ 11.96 hrs, Volume= 0.007 af, Depth> 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 2 YR Rainfall=2.44"

Area (ac)	CN	Description
* 0.040	98	Impervious
0.040		100.00% Impervious Area

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

Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Summary for Pond 3P: UNDERGROUND STORAGE

Inflow Area = 1.717 ac, 81.77% Impervious, Inflow Depth > 1.81" for 2 YR event
 Inflow = 5.09 cfs @ 11.97 hrs, Volume= 0.259 af
 Outflow = 0.98 cfs @ 12.16 hrs, Volume= 0.160 af, Atten= 81%, Lag= 11.6 min
 Primary = 0.98 cfs @ 12.16 hrs, Volume= 0.160 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,121.58' @ 12.16 hrs Surf.Area= 0.073 ac Storage= 0.134 af

Plug-Flow detention time= 214.4 min calculated for 0.159 af (61% of inflow)
 Center-of-Mass det. time= 111.6 min (904.2 - 792.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	1,119.00'	0.104 af	39.00'W x 82.00'L x 7.50'H Field A 0.551 af Overall - 0.291 af Embedded = 0.260 af x 40.0% Voids
#2A	1,119.00'	0.291 af	CMP Round 84 x 16 Inside #1 Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf Overall Size= 84.0"W x 84.0"H x 20.00'L Row Length Adjustment= -7.00' x 38.48 sf x 4 rows 37.00' Header x 38.48 sf x 1 = 1,423.9 cf Inside
		0.395 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	1,119.00'	12.0" Round Culvert L= 191.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,119.00' / 1,116.10' S= 0.0152 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	1,119.00'	1.3" Vert. Orifice/Grate C= 0.600
#3	Device 1	1,121.05'	10.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	1,122.90'	10.0" Vert. Orifice/Grate C= 0.600
#5	Device 1	1,125.90'	6.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.97 cfs @ 12.16 hrs HW=1,121.58' (Free Discharge)

- 1=Culvert (Passes 0.97 cfs of 5.19 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.07 cfs @ 7.65 fps)
- 3=Orifice/Grate (Orifice Controls 0.90 cfs @ 2.47 fps)
- 4=Orifice/Grate (Controls 0.00 cfs)
- 5=Broad-Crested Rectangular Weir(Controls 0.00 cfs)

Pond 3P: UNDERGROUND STORAGE - Chamber Wizard Field A

Chamber Model = CMP Round 84 (Round Corrugated Metal Pipe)

Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf

Overall Size= 84.0"W x 84.0"H x 20.00'L

Row Length Adjustment= -7.00' x 38.48 sf x 4 rows

84.0" Wide + 36.0" Spacing = 120.0" C-C Row Spacing

4 Chambers/Row x 20.00' Long -7.00' Row Adjustment +7.00' Header x 1 = 80.00' Row Length +12.0" End Stone x 2 = 82.00' Base Length

4 Rows x 84.0" Wide + 36.0" Spacing x 3 + 12.0" Side Stone x 2 = 39.00' Base Width

84.0" Chamber Height + 6.0" Cover = 7.50' Field Height

16 Chambers x 769.7 cf -7.00' Row Adjustment x 38.48 sf x 4 Rows + 37.00' Header x 38.48 sf =
12,661.4 cf Chamber Storage

23,985.0 cf Field - 12,661.4 cf Chambers = 11,323.6 cf Stone x 40.0% Voids = 4,529.4 cf Stone Storage

Chamber Storage + Stone Storage = 17,190.8 cf = 0.395 af

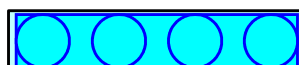
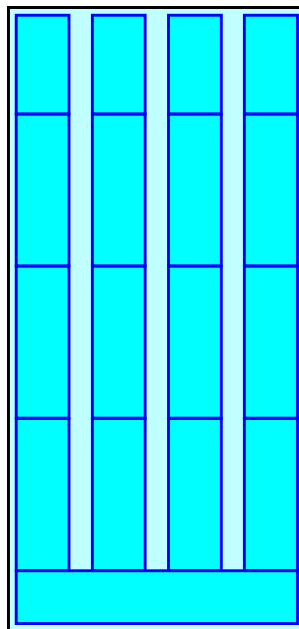
Overall Storage Efficiency = 71.7%

Overall System Size = 82.00' x 39.00' x 7.50'

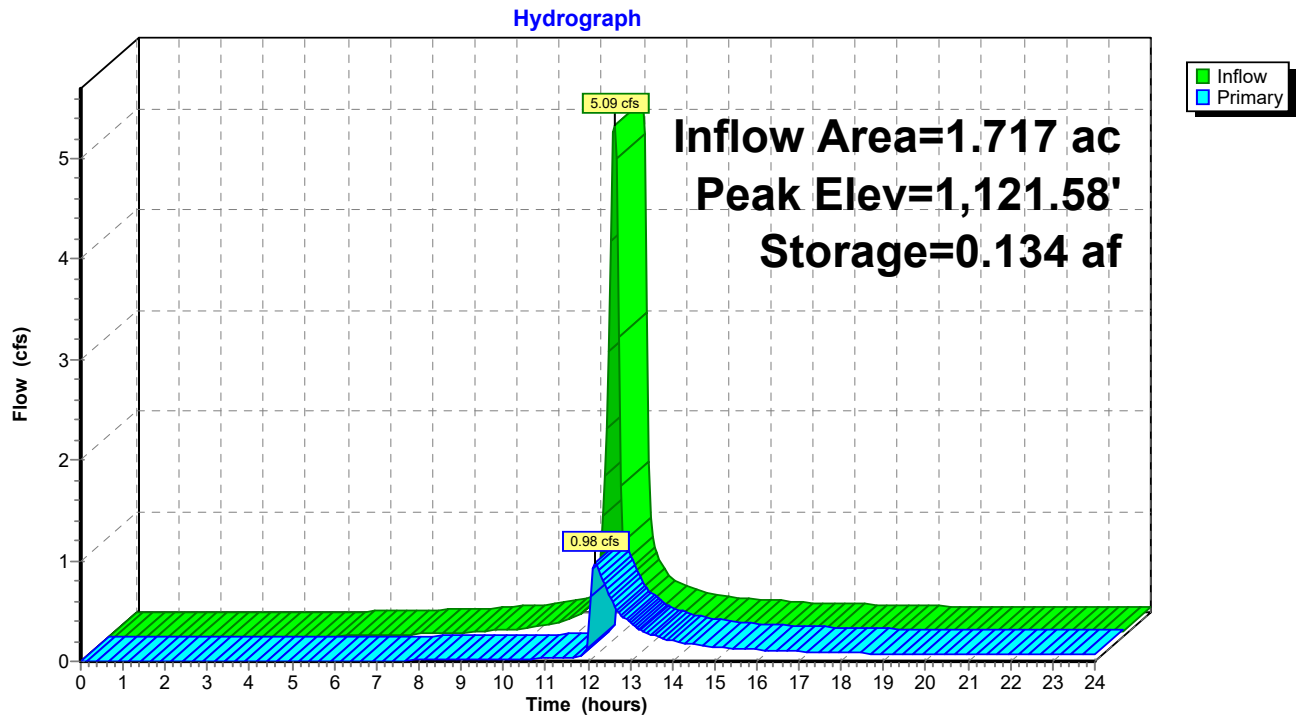
16 Chambers

888.3 cy Field

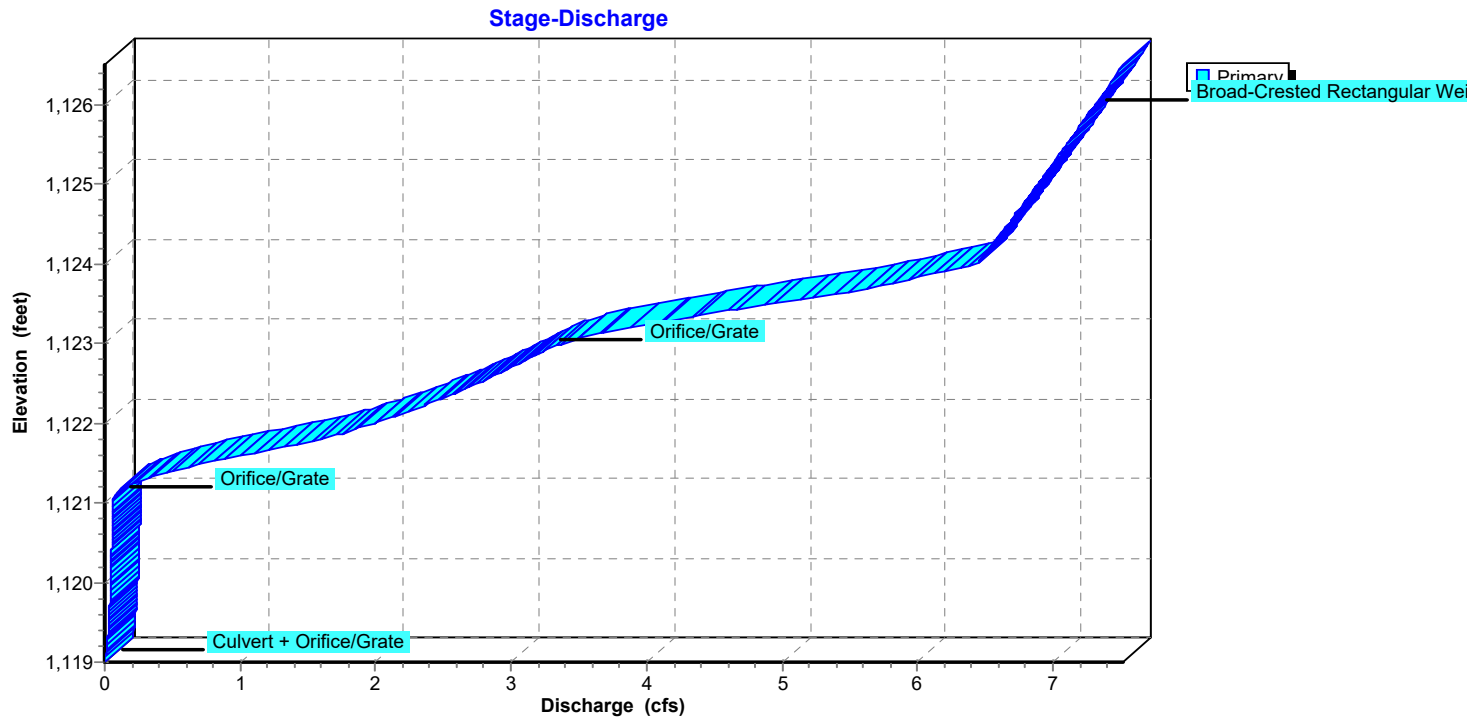
419.4 cy Stone



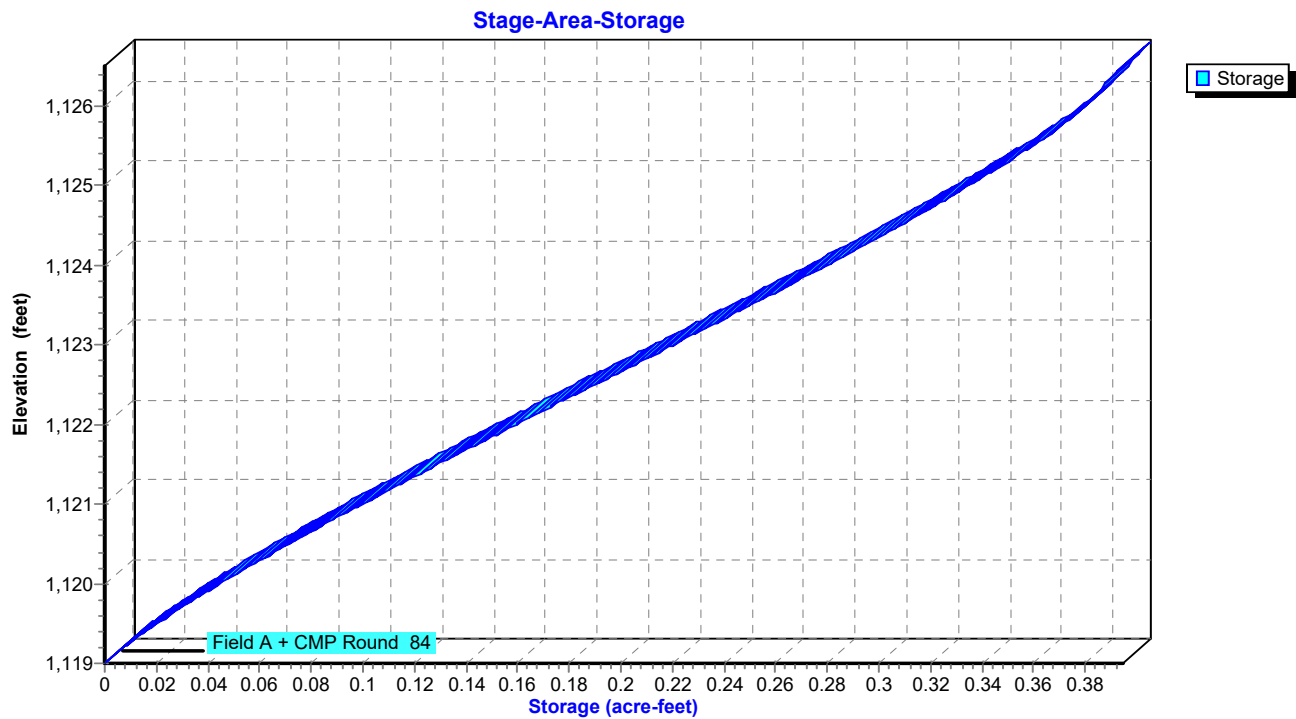
Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE

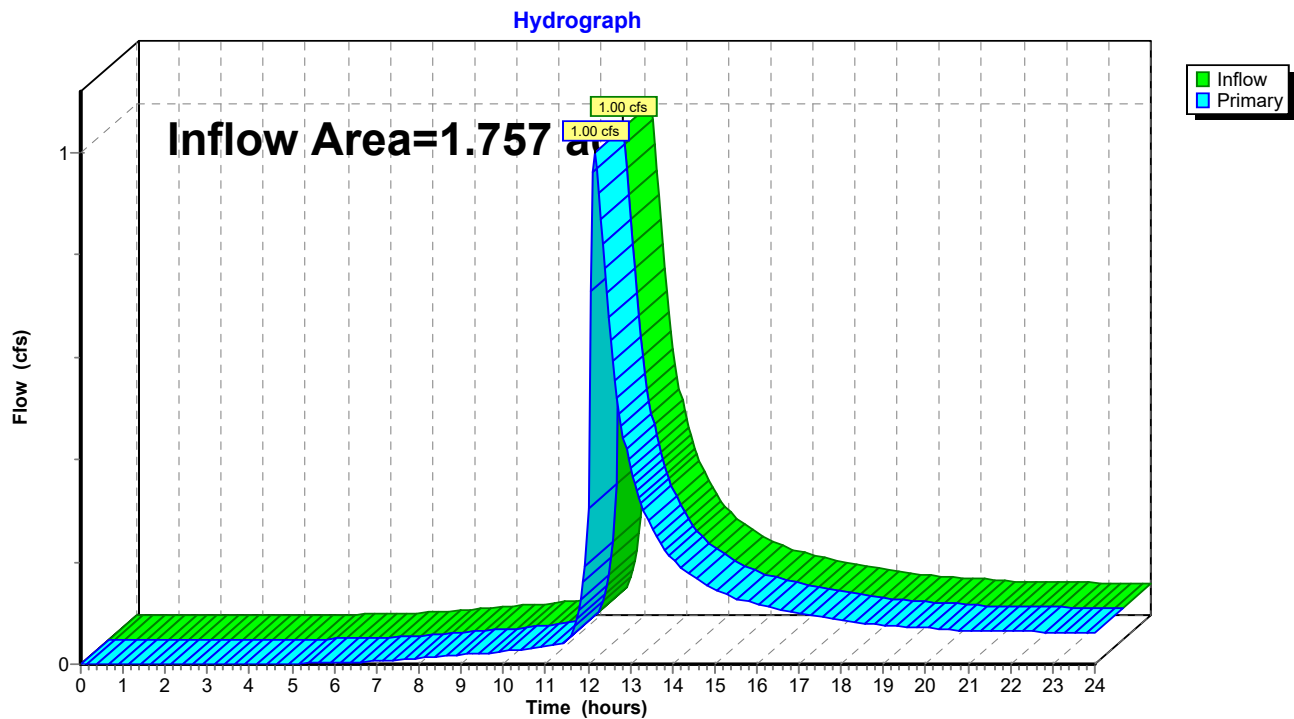


Summary for Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow Area = 1.757 ac, 82.19% Impervious, Inflow Depth > 1.14" for 2 YR event
 Inflow = 1.00 cfs @ 12.15 hrs, Volume= 0.167 af
 Primary = 1.00 cfs @ 12.15 hrs, Volume= 0.167 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE



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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: TOTAL PRE

Runoff Area=1.757 ac 0.00% Impervious Runoff Depth>0.93"
Flow Length=310' Tc=12.1 min CN=74 Runoff=2.24 cfs 0.136 af

Subcatchment2S: POST DEVELOPMENT

Runoff Area=1.717 ac 81.77% Impervious Runoff Depth>2.39"
Tc=6.0 min CN=94 Runoff=6.59 cfs 0.341 af

Subcatchment4S: POST DEVELOPMENT

Runoff Area=0.040 ac 100.00% Impervious Runoff Depth>2.81"
Tc=6.0 min CN=98 Runoff=0.17 cfs 0.009 af

Pond 3P: UNDERGROUND STORAGE

Peak Elev=1,122.09' Storage=0.165 af Inflow=6.59 cfs 0.341 af
Outflow=2.15 cfs 0.238 af

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow=2.19 cfs 0.248 af
Primary=2.19 cfs 0.248 af

Total Runoff Area = 3.514 ac Runoff Volume = 0.487 af Average Runoff Depth = 1.66"
58.91% Pervious = 2.070 ac 41.09% Impervious = 1.444 ac

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Type II 24-hr 5 YR Rainfall=3.04"

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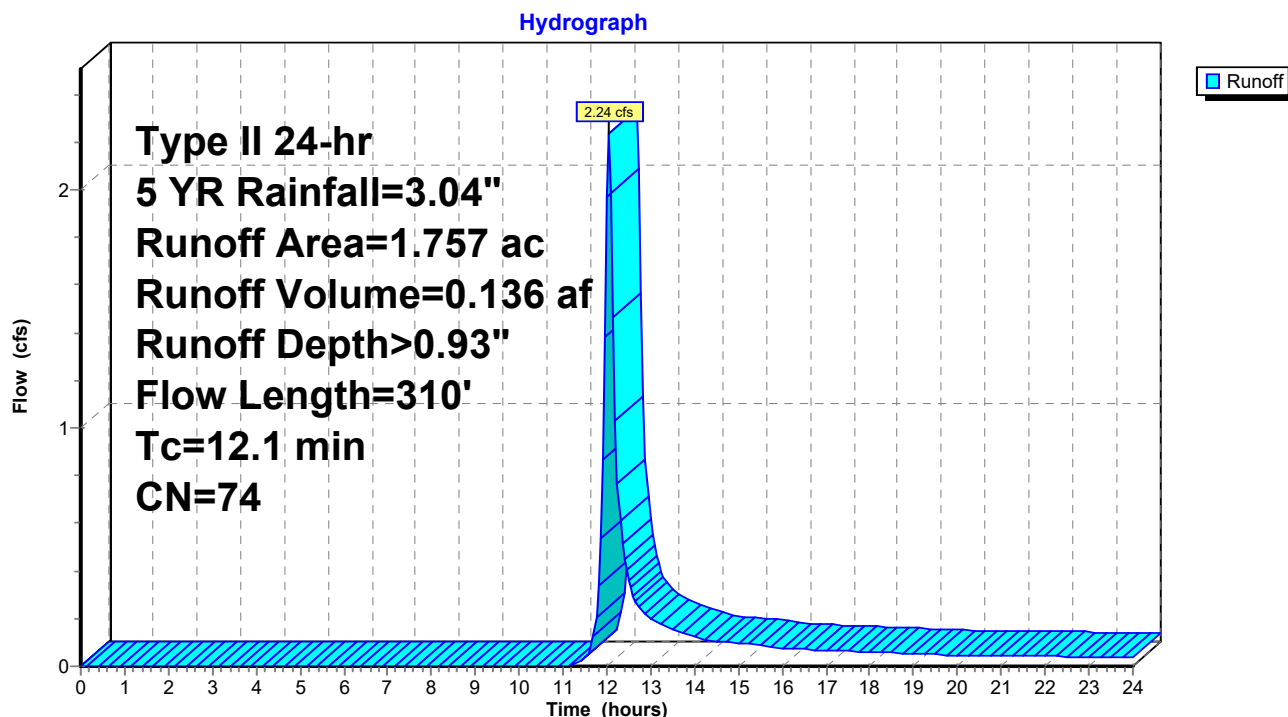
Summary for Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

Runoff = 2.24 cfs @ 12.05 hrs, Volume= 0.136 af, Depth> 0.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 5 YR Rainfall=3.04"

Area (ac)	CN	Description
* 1.757	74	Existing Lawn Area
1.757		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	100	0.0200	0.15		Sheet Flow, Sheet Flow Grass: Short n= 0.150 P2= 2.44"
0.3	95	0.1100	5.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
0.6	115	0.0430	3.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
12.1	310	Total			

Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

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Type II 24-hr 5 YR Rainfall=3.04"

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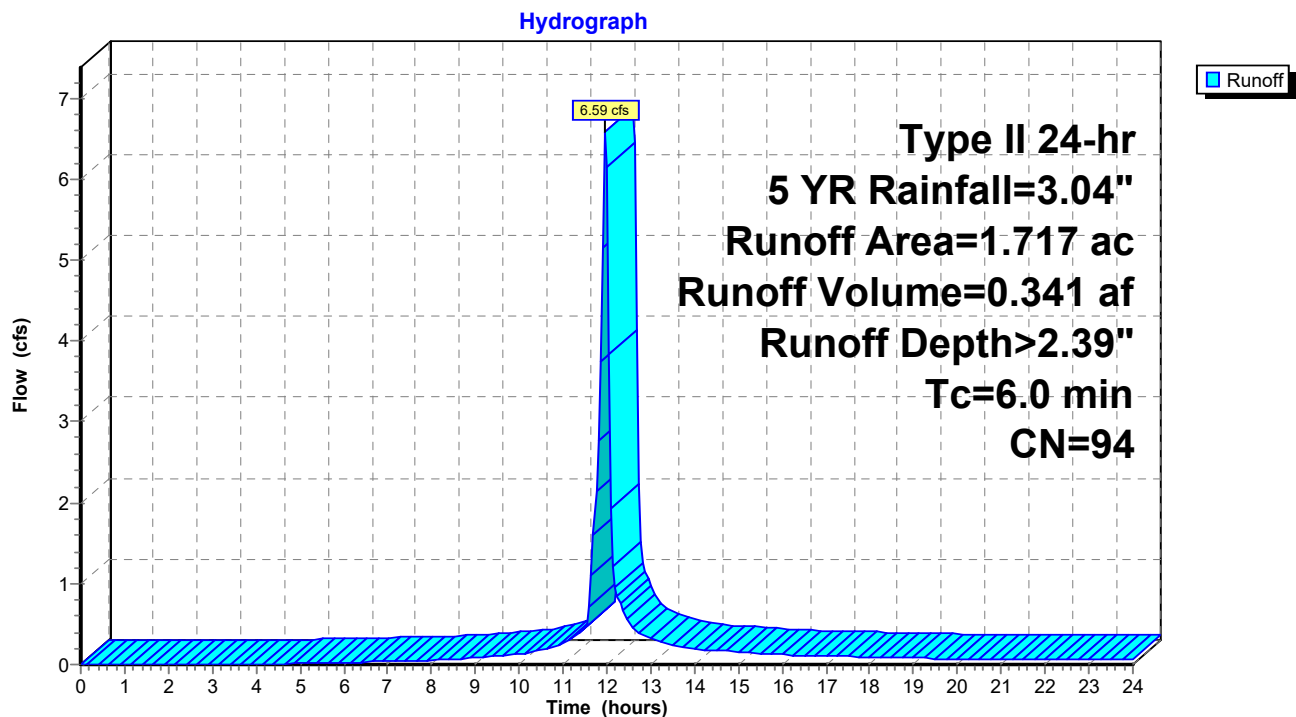
Summary for Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

Runoff = 6.59 cfs @ 11.96 hrs, Volume= 0.341 af, Depth> 2.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 5 YR Rainfall=3.04"

Area (ac)	CN	Description
* 1.404	98	Impervious
* 0.313	74	Open
1.717	94	Weighted Average
0.313		18.23% Pervious Area
1.404		81.77% Impervious Area

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

Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

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Type II 24-hr 5 YR Rainfall=3.04"

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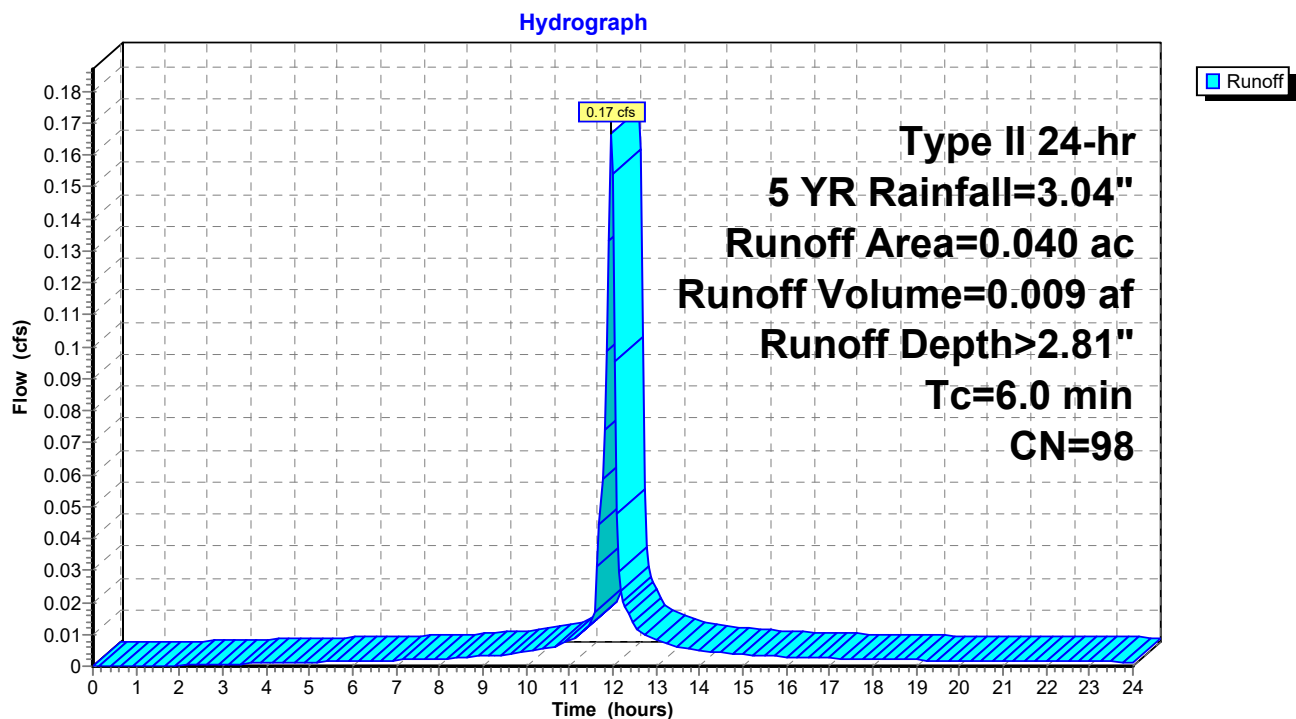
Summary for Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Runoff = 0.17 cfs @ 11.96 hrs, Volume= 0.009 af, Depth> 2.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 5 YR Rainfall=3.04"

Area (ac)	CN	Description
* 0.040	98	Impervious
0.040		100.00% Impervious Area

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

Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Summary for Pond 3P: UNDERGROUND STORAGE

Inflow Area = 1.717 ac, 81.77% Impervious, Inflow Depth > 2.39" for 5 YR event
 Inflow = 6.59 cfs @ 11.96 hrs, Volume= 0.341 af
 Outflow = 2.15 cfs @ 12.10 hrs, Volume= 0.238 af, Atten= 67%, Lag= 8.4 min
 Primary = 2.15 cfs @ 12.10 hrs, Volume= 0.238 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,122.09' @ 12.10 hrs Surf.Area= 0.073 ac Storage= 0.165 af

Plug-Flow detention time= 175.2 min calculated for 0.238 af (70% of inflow)
 Center-of-Mass det. time= 80.8 min (865.8 - 785.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	1,119.00'	0.104 af	39.00'W x 82.00'L x 7.50'H Field A 0.551 af Overall - 0.291 af Embedded = 0.260 af x 40.0% Voids
#2A	1,119.00'	0.291 af	CMP Round 84 x 16 Inside #1 Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf Overall Size= 84.0"W x 84.0"H x 20.00'L Row Length Adjustment= -7.00' x 38.48 sf x 4 rows 37.00' Header x 38.48 sf x 1 = 1,423.9 cf Inside
			0.395 af Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	1,119.00'	12.0" Round Culvert L= 191.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,119.00' / 1,116.10' S= 0.0152 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	1,119.00'	1.3" Vert. Orifice/Grate C= 0.600
#3	Device 1	1,121.05'	10.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	1,122.90'	10.0" Vert. Orifice/Grate C= 0.600
#5	Device 1	1,125.90'	6.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=2.14 cfs @ 12.10 hrs HW=1,122.08' (Free Discharge)

- 1=Culvert (Passes 2.14 cfs of 5.47 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.08 cfs @ 8.38 fps)
- 3=Orifice/Grate (Orifice Controls 2.06 cfs @ 3.78 fps)
- 4=Orifice/Grate (Controls 0.00 cfs)
- 5=Broad-Crested Rectangular Weir(Controls 0.00 cfs)

Pond 3P: UNDERGROUND STORAGE - Chamber Wizard Field A

Chamber Model = CMP Round 84 (Round Corrugated Metal Pipe)

Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf

Overall Size= 84.0"W x 84.0"H x 20.00'L

Row Length Adjustment= -7.00' x 38.48 sf x 4 rows

84.0" Wide + 36.0" Spacing = 120.0" C-C Row Spacing

4 Chambers/Row x 20.00' Long -7.00' Row Adjustment +7.00' Header x 1 = 80.00' Row Length +12.0" End Stone x 2 = 82.00' Base Length

4 Rows x 84.0" Wide + 36.0" Spacing x 3 + 12.0" Side Stone x 2 = 39.00' Base Width

84.0" Chamber Height + 6.0" Cover = 7.50' Field Height

16 Chambers x 769.7 cf -7.00' Row Adjustment x 38.48 sf x 4 Rows + 37.00' Header x 38.48 sf =
12,661.4 cf Chamber Storage

23,985.0 cf Field - 12,661.4 cf Chambers = 11,323.6 cf Stone x 40.0% Voids = 4,529.4 cf Stone Storage

Chamber Storage + Stone Storage = 17,190.8 cf = 0.395 af

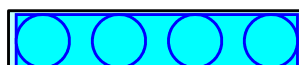
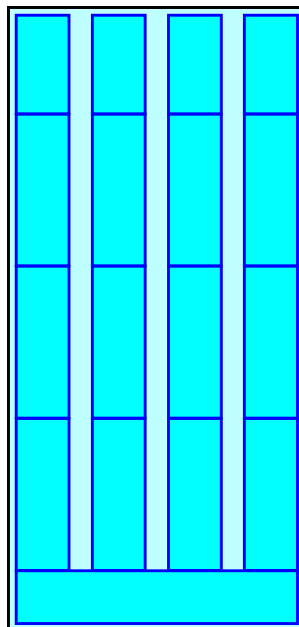
Overall Storage Efficiency = 71.7%

Overall System Size = 82.00' x 39.00' x 7.50'

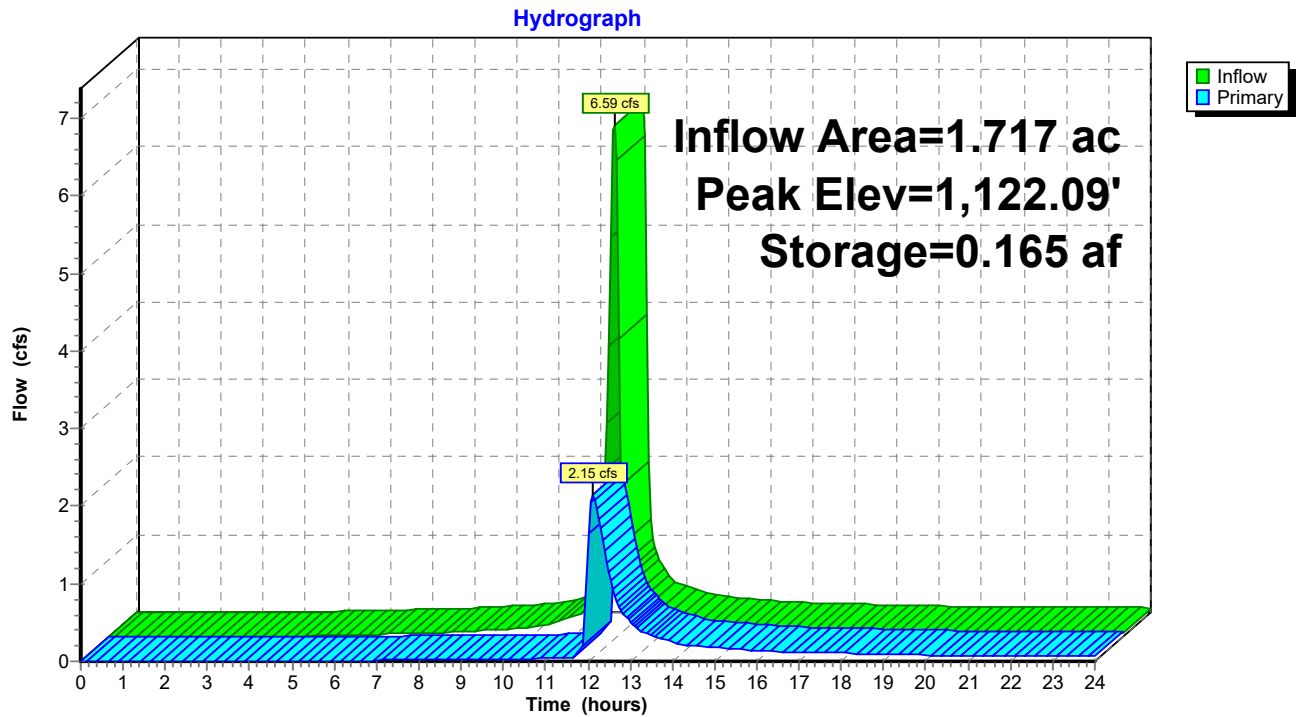
16 Chambers

888.3 cy Field

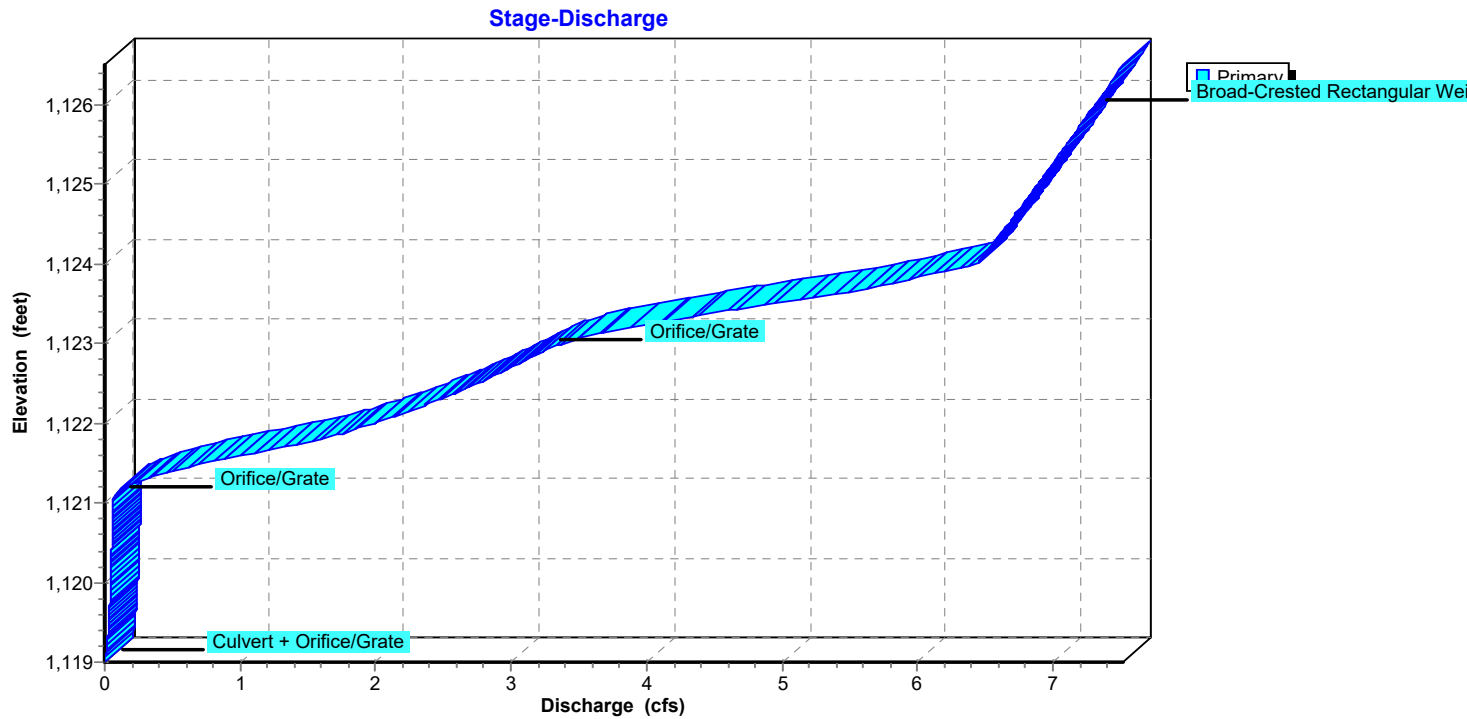
419.4 cy Stone



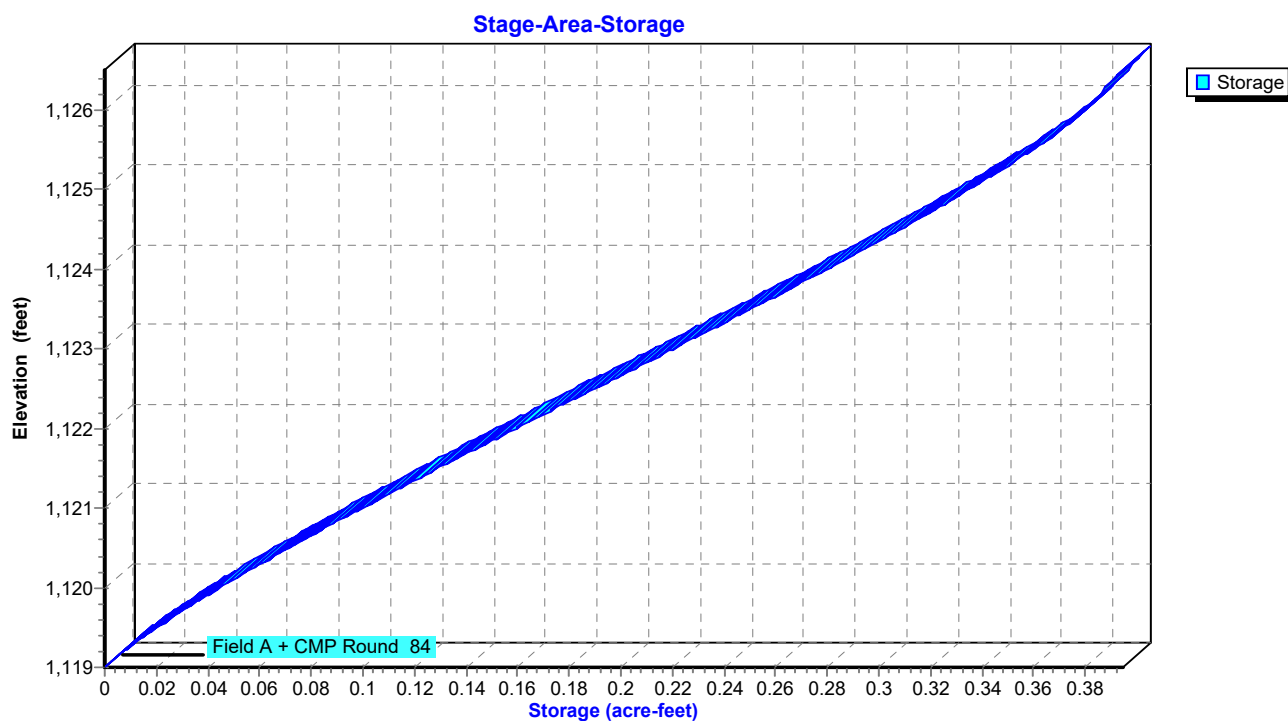
Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE

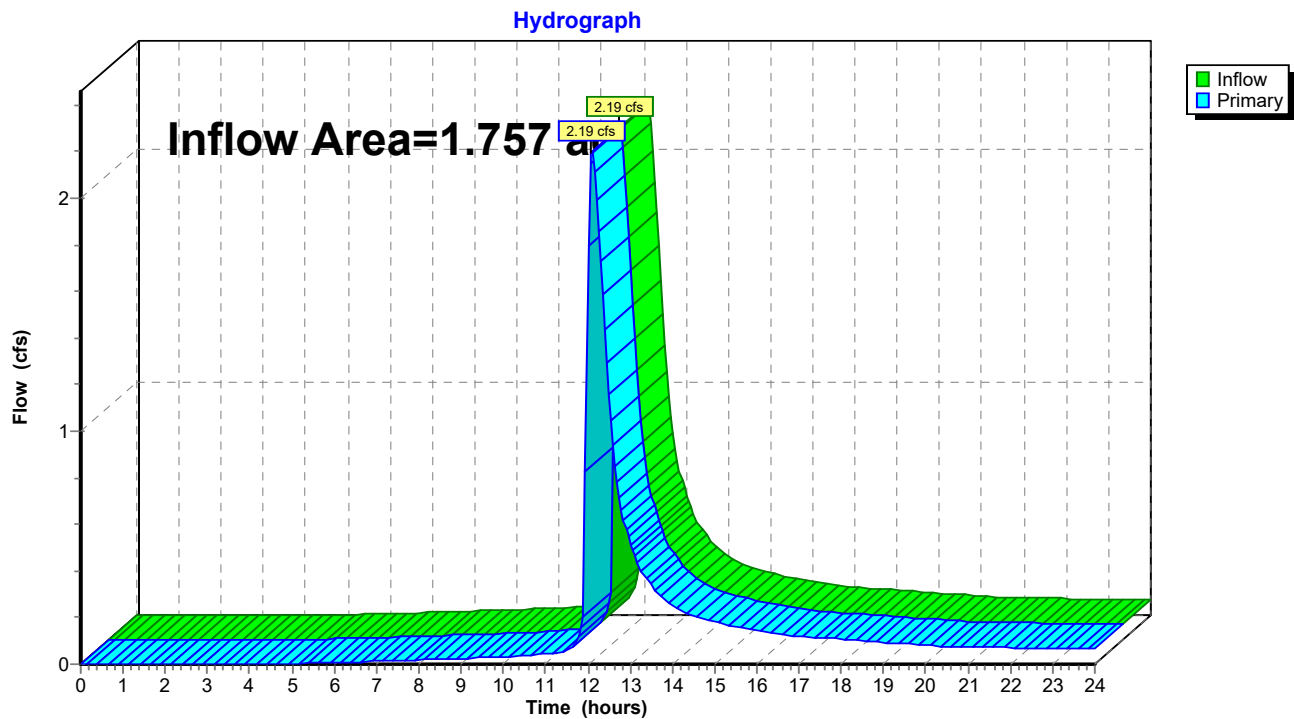


Summary for Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow Area = 1.757 ac, 82.19% Impervious, Inflow Depth > 1.69" for 5 YR event
 Inflow = 2.19 cfs @ 12.09 hrs, Volume= 0.248 af
 Primary = 2.19 cfs @ 12.09 hrs, Volume= 0.248 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE



Site TR-55 Final*Type II 24-hr 10 YR Rainfall=3.56"*

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: TOTAL PRE

Runoff Area=1.757 ac 0.00% Impervious Runoff Depth>1.28"
Flow Length=310' Tc=12.1 min CN=74 Runoff=3.13 cfs 0.187 af

Subcatchment2S: POST DEVELOPMENT

Runoff Area=1.717 ac 81.77% Impervious Runoff Depth>2.89"
Tc=6.0 min CN=94 Runoff=7.89 cfs 0.414 af

Subcatchment4S: POST DEVELOPMENT

Runoff Area=0.040 ac 100.00% Impervious Runoff Depth>3.32"
Tc=6.0 min CN=98 Runoff=0.20 cfs 0.011 af

Pond 3P: UNDERGROUND STORAGE

Peak Elev=1,122.54' Storage=0.193 af Inflow=7.89 cfs 0.414 af
Outflow=2.81 cfs 0.309 af

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow=2.88 cfs 0.320 af
Primary=2.88 cfs 0.320 af

Total Runoff Area = 3.514 ac Runoff Volume = 0.612 af Average Runoff Depth = 2.09"
58.91% Pervious = 2.070 ac 41.09% Impervious = 1.444 ac

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Type II 24-hr 10 YR Rainfall=3.56"

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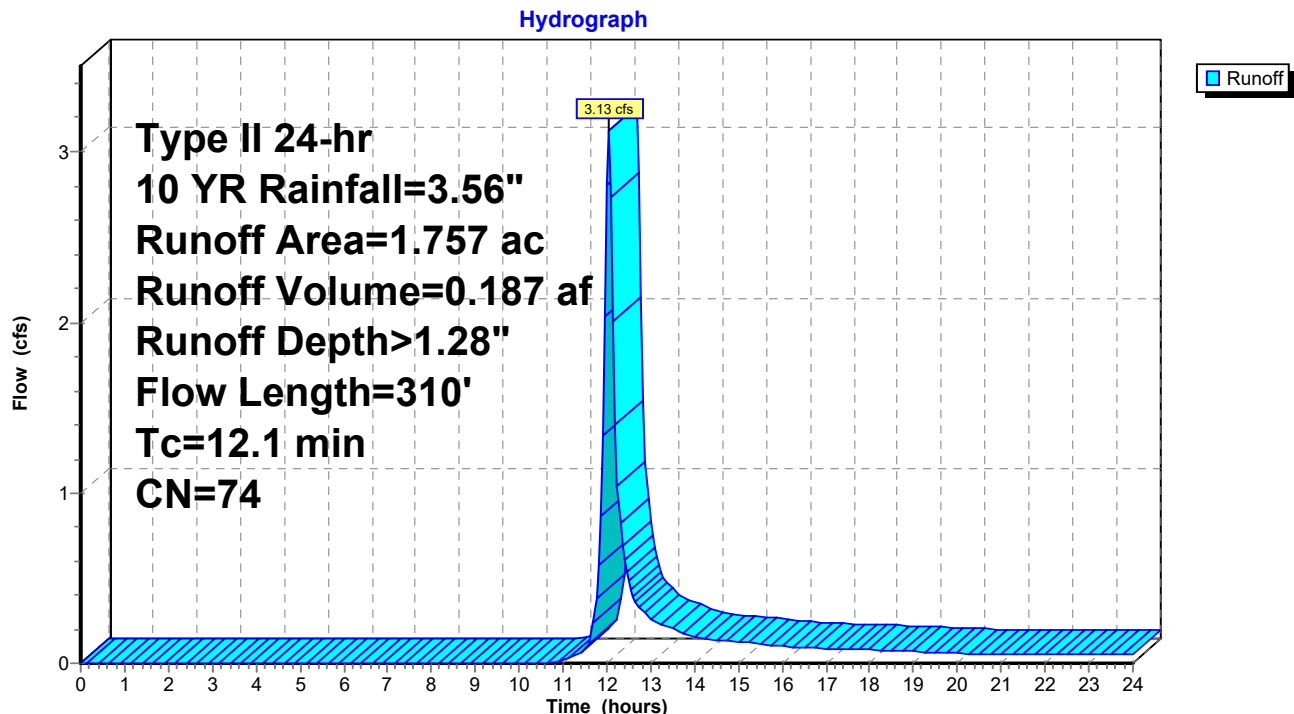
Summary for Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

Runoff = 3.13 cfs @ 12.05 hrs, Volume= 0.187 af, Depth> 1.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 10 YR Rainfall=3.56"

Area (ac)	CN	Description
* 1.757	74	Existing Lawn Area
1.757		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	100	0.0200	0.15		Sheet Flow, Sheet Flow Grass: Short n= 0.150 P2= 2.44"
0.3	95	0.1100	5.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
0.6	115	0.0430	3.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
12.1	310	Total			

Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

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Type II 24-hr 10 YR Rainfall=3.56"

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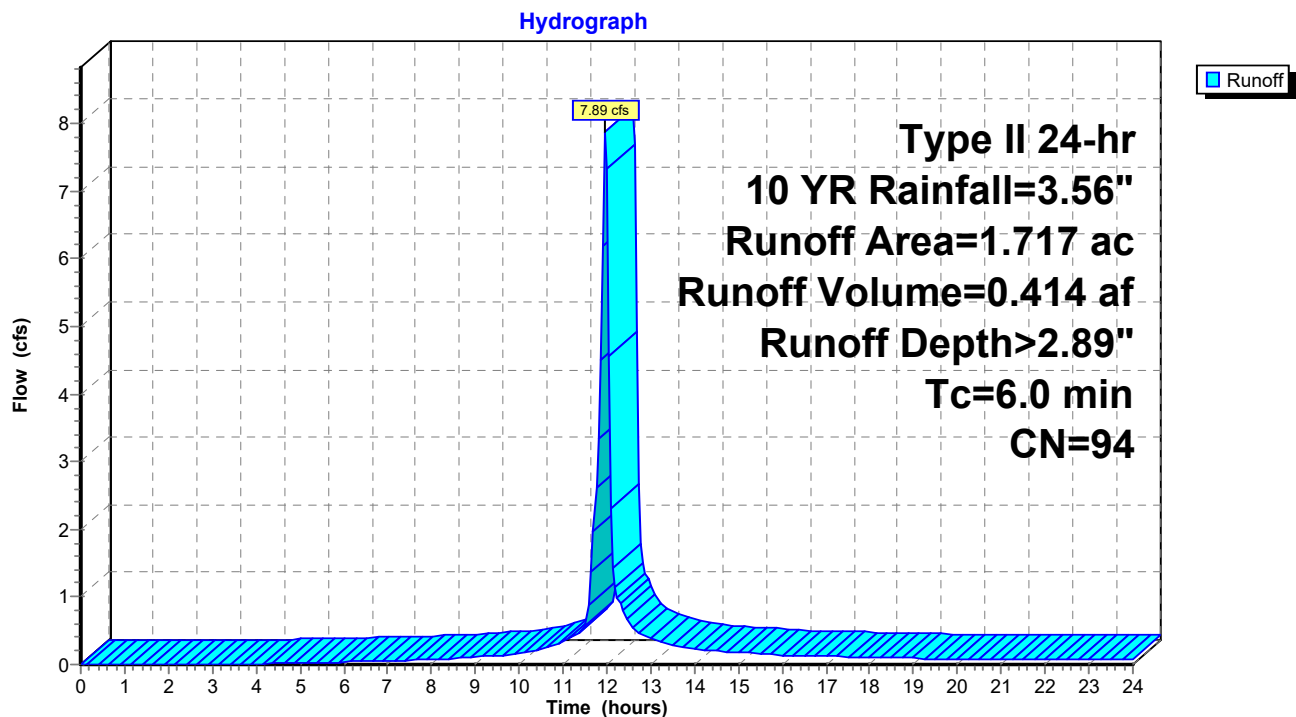
Summary for Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

Runoff = 7.89 cfs @ 11.96 hrs, Volume= 0.414 af, Depth> 2.89"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 10 YR Rainfall=3.56"

Area (ac)	CN	Description
* 1.404	98	Impervious
* 0.313	74	Open
1.717	94	Weighted Average
0.313		18.23% Pervious Area
1.404		81.77% Impervious Area

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

Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

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Type II 24-hr 10 YR Rainfall=3.56"

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Summary for Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Runoff = 0.20 cfs @ 11.96 hrs, Volume= 0.011 af, Depth> 3.32"

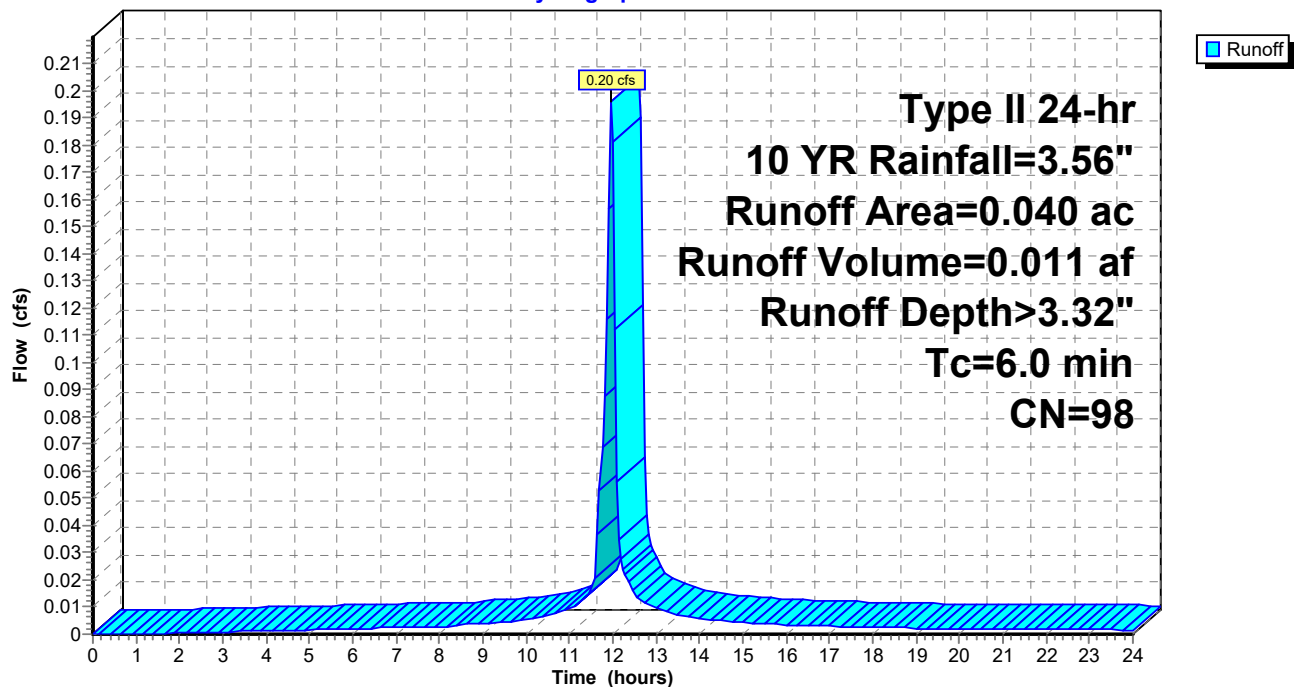
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 10 YR Rainfall=3.56"

Area (ac)	CN	Description
* 0.040	98	Impervious
0.040		100.00% Impervious Area

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

Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Hydrograph



Summary for Pond 3P: UNDERGROUND STORAGE

Inflow Area = 1.717 ac, 81.77% Impervious, Inflow Depth > 2.89" for 10 YR event
 Inflow = 7.89 cfs @ 11.96 hrs, Volume= 0.414 af
 Outflow = 2.81 cfs @ 12.10 hrs, Volume= 0.309 af, Atten= 64%, Lag= 7.9 min
 Primary = 2.81 cfs @ 12.10 hrs, Volume= 0.309 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,122.54' @ 12.10 hrs Surf.Area= 0.073 ac Storage= 0.193 af

Plug-Flow detention time= 158.9 min calculated for 0.309 af (75% of inflow)
 Center-of-Mass det. time= 70.0 min (849.7 - 779.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	1,119.00'	0.104 af	39.00'W x 82.00'L x 7.50'H Field A 0.551 af Overall - 0.291 af Embedded = 0.260 af x 40.0% Voids
#2A	1,119.00'	0.291 af	CMP Round 84 x 16 Inside #1 Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf Overall Size= 84.0"W x 84.0"H x 20.00'L Row Length Adjustment= -7.00' x 38.48 sf x 4 rows 37.00' Header x 38.48 sf x 1 = 1,423.9 cf Inside
0.395 af			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	1,119.00'	12.0" Round Culvert L= 191.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,119.00' / 1,116.10' S= 0.0152 ' / ' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	1,119.00'	1.3" Vert. Orifice/Grate C= 0.600
#3	Device 1	1,121.05'	10.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	1,122.90'	10.0" Vert. Orifice/Grate C= 0.600
#5	Device 1	1,125.90'	6.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=2.80 cfs @ 12.10 hrs HW=1,122.54' (Free Discharge)

- 1=Culvert (Passes 2.80 cfs of 5.72 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.08 cfs @ 8.99 fps)
- 3=Orifice/Grate (Orifice Controls 2.72 cfs @ 4.99 fps)
- 4=Orifice/Grate (Controls 0.00 cfs)
- 5=Broad-Crested Rectangular Weir(Controls 0.00 cfs)

Pond 3P: UNDERGROUND STORAGE - Chamber Wizard Field A

Chamber Model = CMP Round 84 (Round Corrugated Metal Pipe)

Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf

Overall Size= 84.0"W x 84.0"H x 20.00'L

Row Length Adjustment= -7.00' x 38.48 sf x 4 rows

84.0" Wide + 36.0" Spacing = 120.0" C-C Row Spacing

4 Chambers/Row x 20.00' Long -7.00' Row Adjustment +7.00' Header x 1 = 80.00' Row Length +12.0" End Stone x 2 = 82.00' Base Length

4 Rows x 84.0" Wide + 36.0" Spacing x 3 + 12.0" Side Stone x 2 = 39.00' Base Width

84.0" Chamber Height + 6.0" Cover = 7.50' Field Height

16 Chambers x 769.7 cf -7.00' Row Adjustment x 38.48 sf x 4 Rows + 37.00' Header x 38.48 sf =
12,661.4 cf Chamber Storage

23,985.0 cf Field - 12,661.4 cf Chambers = 11,323.6 cf Stone x 40.0% Voids = 4,529.4 cf Stone Storage

Chamber Storage + Stone Storage = 17,190.8 cf = 0.395 af

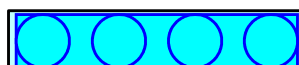
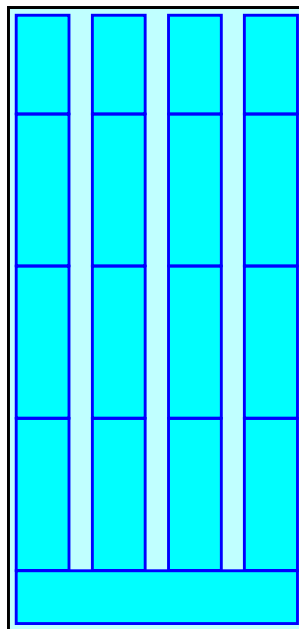
Overall Storage Efficiency = 71.7%

Overall System Size = 82.00' x 39.00' x 7.50'

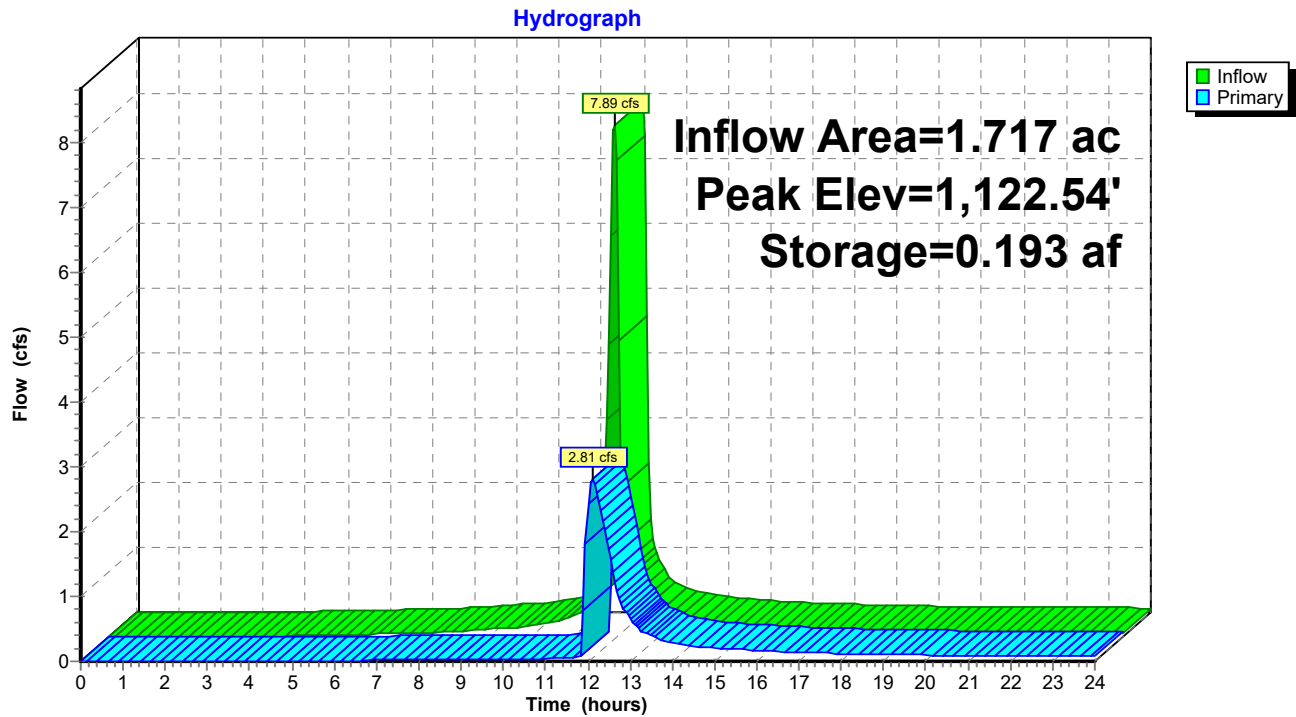
16 Chambers

888.3 cy Field

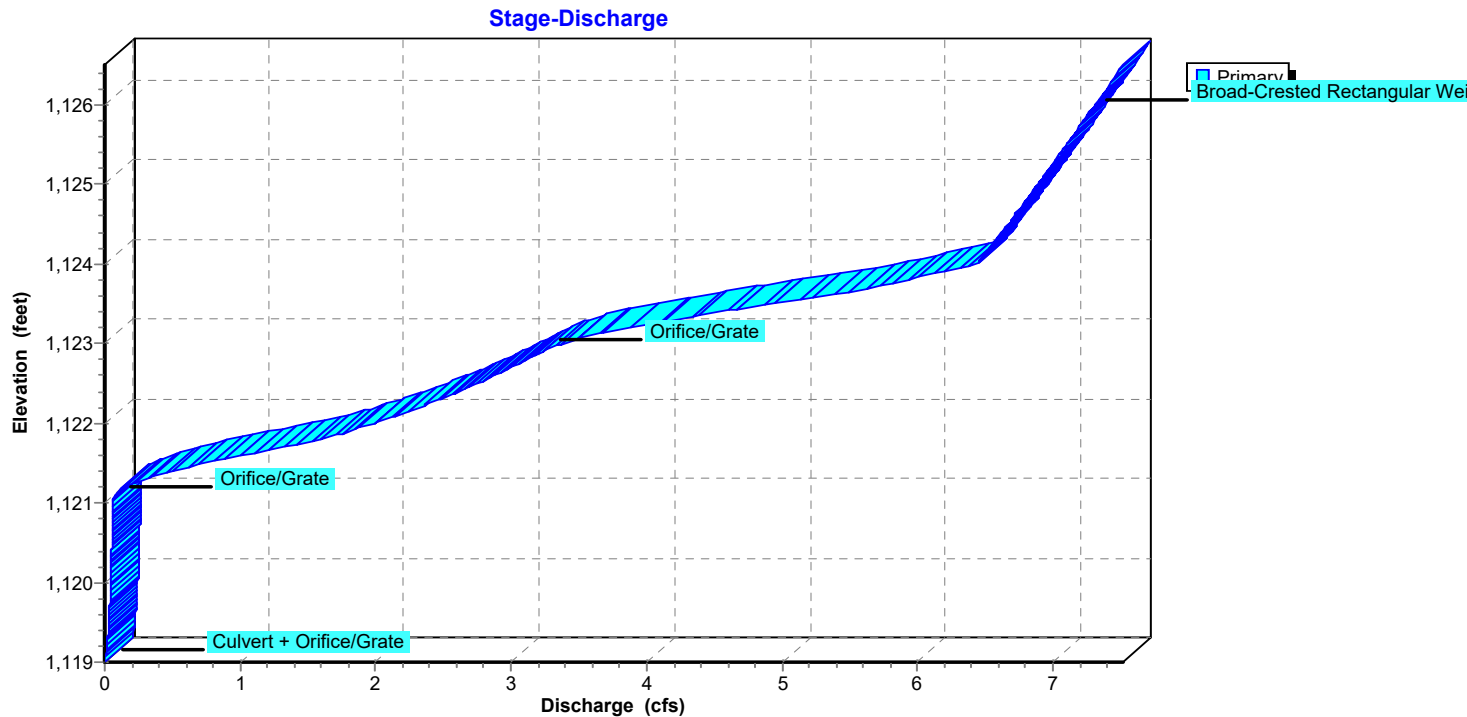
419.4 cy Stone



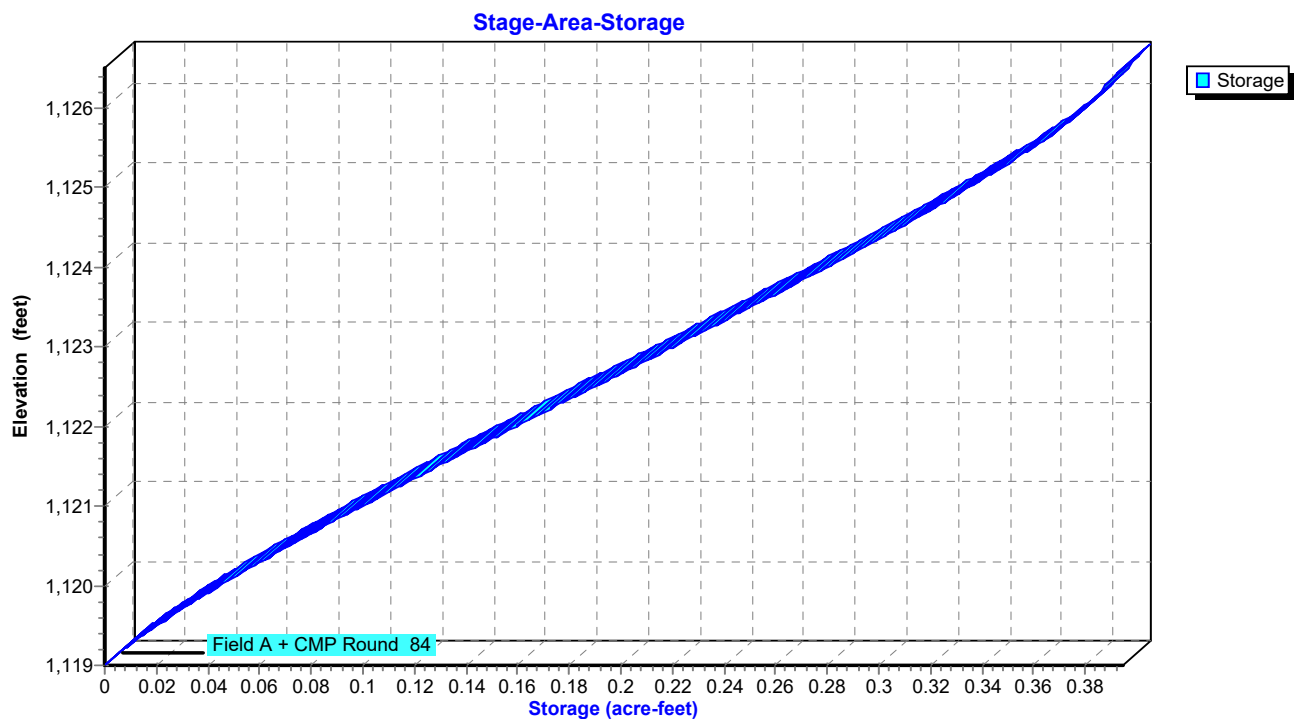
Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE

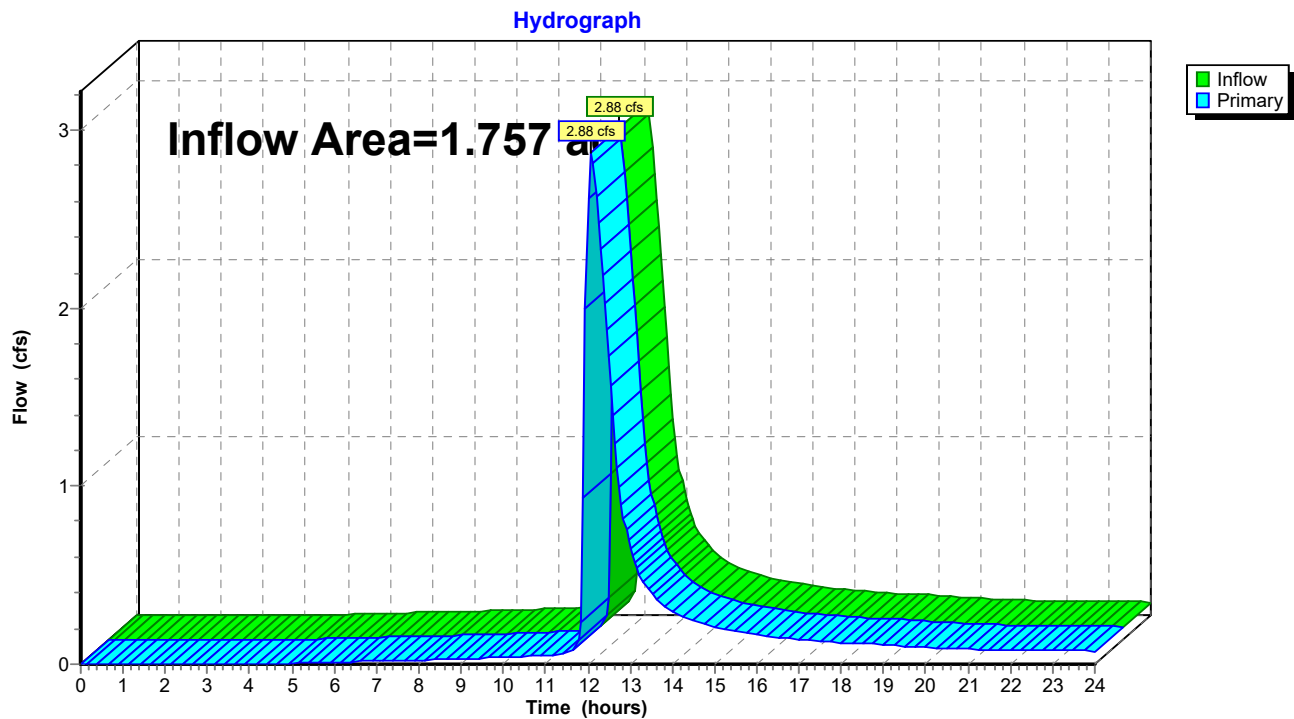


Summary for Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow Area = 1.757 ac, 82.19% Impervious, Inflow Depth > 2.18" for 10 YR event
 Inflow = 2.88 cfs @ 12.08 hrs, Volume= 0.320 af
 Primary = 2.88 cfs @ 12.08 hrs, Volume= 0.320 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE



Site TR-55 Final*Type II 24-hr 25 YR Rainfall=4.33"*

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: TOTAL PRE

Runoff Area=1.757 ac 0.00% Impervious Runoff Depth>1.84"
Flow Length=310' Tc=12.1 min CN=74 Runoff=4.56 cfs 0.269 af

Subcatchment2S: POST DEVELOPMENT

Runoff Area=1.717 ac 81.77% Impervious Runoff Depth>3.65"
Tc=6.0 min CN=94 Runoff=9.80 cfs 0.522 af

Subcatchment4S: POST DEVELOPMENT

Runoff Area=0.040 ac 100.00% Impervious Runoff Depth>4.09"
Tc=6.0 min CN=98 Runoff=0.24 cfs 0.014 af

Pond 3P: UNDERGROUND STORAGE

Peak Elev=1,123.20' Storage=0.232 af Inflow=9.80 cfs 0.522 af
Outflow=3.87 cfs 0.415 af

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow=3.96 cfs 0.429 af
Primary=3.96 cfs 0.429 af

Total Runoff Area = 3.514 ac Runoff Volume = 0.804 af Average Runoff Depth = 2.75"
58.91% Pervious = 2.070 ac 41.09% Impervious = 1.444 ac

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Type II 24-hr 25 YR Rainfall=4.33"

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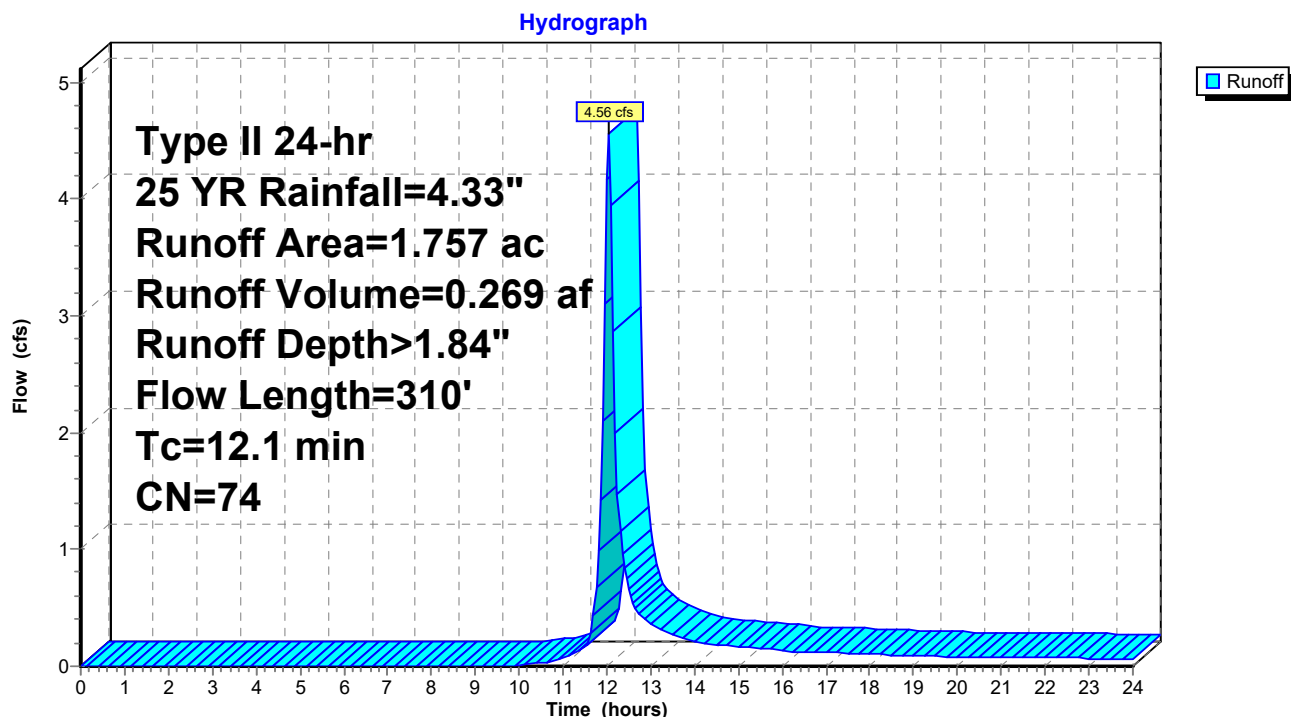
Summary for Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

Runoff = 4.56 cfs @ 12.04 hrs, Volume= 0.269 af, Depth> 1.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 YR Rainfall=4.33"

Area (ac)	CN	Description
* 1.757	74	Existing Lawn Area
1.757		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	100	0.0200	0.15		Sheet Flow, Sheet Flow Grass: Short n= 0.150 P2= 2.44"
0.3	95	0.1100	5.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
0.6	115	0.0430	3.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
12.1	310	Total			

Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

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Type II 24-hr 25 YR Rainfall=4.33"

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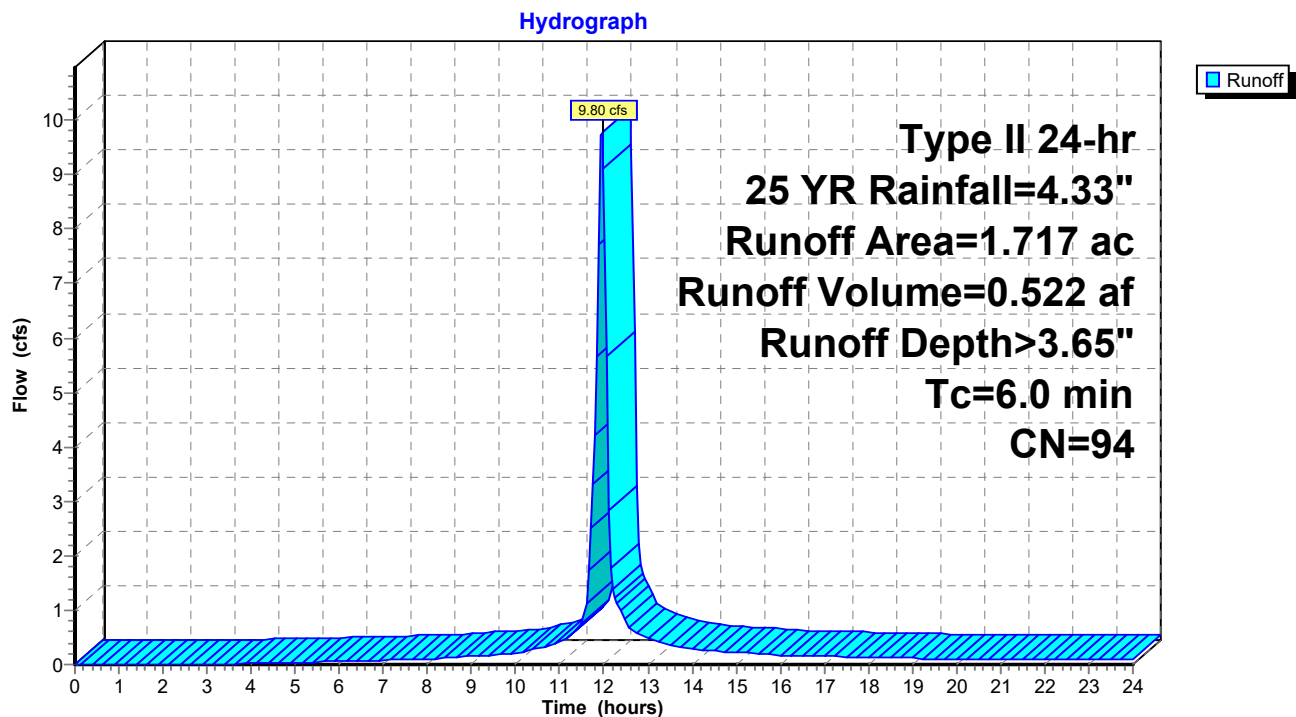
Summary for Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

Runoff = 9.80 cfs @ 11.96 hrs, Volume= 0.522 af, Depth> 3.65"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 YR Rainfall=4.33"

Area (ac)	CN	Description
* 1.404	98	Impervious
* 0.313	74	Open
1.717	94	Weighted Average
0.313		18.23% Pervious Area
1.404		81.77% Impervious Area

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

Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

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Type II 24-hr 25 YR Rainfall=4.33"

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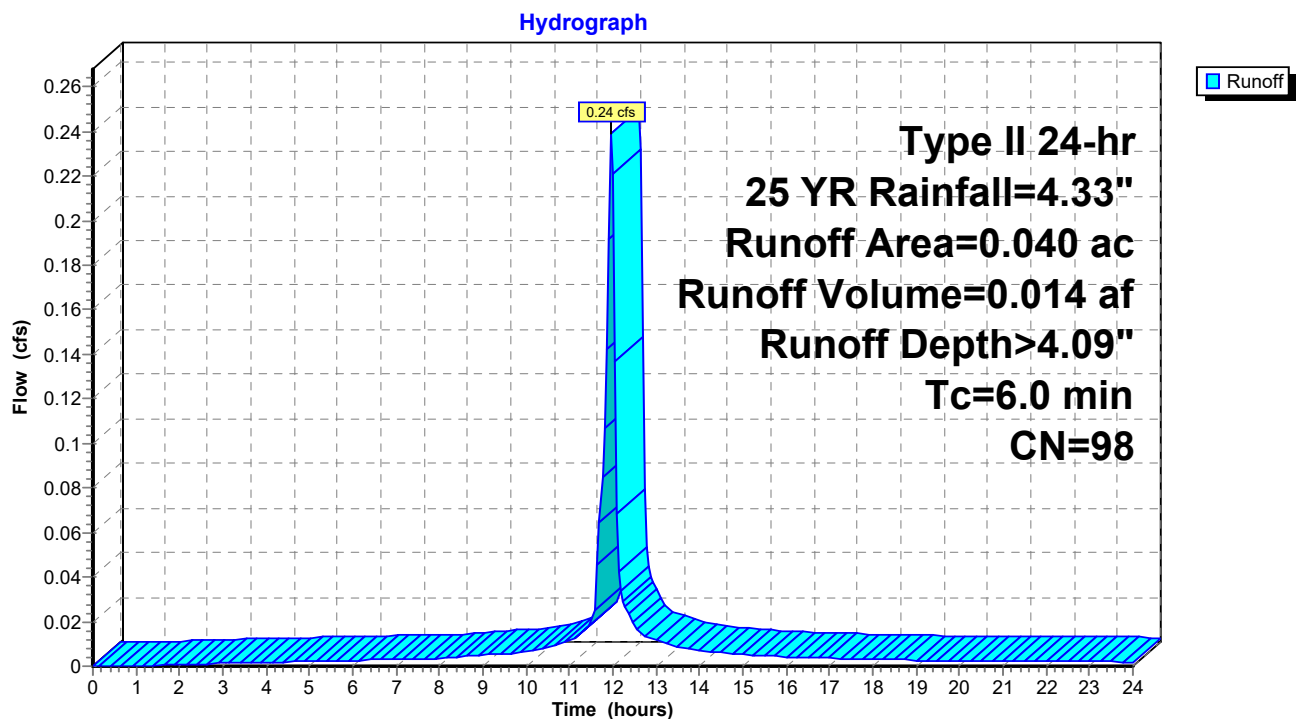
Summary for Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Runoff = 0.24 cfs @ 11.96 hrs, Volume= 0.014 af, Depth> 4.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 25 YR Rainfall=4.33"

Area (ac)	CN	Description
* 0.040	98	Impervious
0.040		100.00% Impervious Area

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

Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Summary for Pond 3P: UNDERGROUND STORAGE

Inflow Area = 1.717 ac, 81.77% Impervious, Inflow Depth > 3.65" for 25 YR event
 Inflow = 9.80 cfs @ 11.96 hrs, Volume= 0.522 af
 Outflow = 3.87 cfs @ 12.09 hrs, Volume= 0.415 af, Atten= 60%, Lag= 7.4 min
 Primary = 3.87 cfs @ 12.09 hrs, Volume= 0.415 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,123.20' @ 12.09 hrs Surf.Area= 0.073 ac Storage= 0.232 af

Plug-Flow detention time= 143.0 min calculated for 0.414 af (79% of inflow)
 Center-of-Mass det. time= 63.6 min (837.3 - 773.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	1,119.00'	0.104 af	39.00'W x 82.00'L x 7.50'H Field A 0.551 af Overall - 0.291 af Embedded = 0.260 af x 40.0% Voids
#2A	1,119.00'	0.291 af	CMP Round 84 x 16 Inside #1 Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf Overall Size= 84.0"W x 84.0"H x 20.00'L Row Length Adjustment= -7.00' x 38.48 sf x 4 rows 37.00' Header x 38.48 sf x 1 = 1,423.9 cf Inside
0.395 af			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	1,119.00'	12.0" Round Culvert L= 191.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,119.00' / 1,116.10' S= 0.0152 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	1,119.00'	1.3" Vert. Orifice/Grate C= 0.600
#3	Device 1	1,121.05'	10.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	1,122.90'	10.0" Vert. Orifice/Grate C= 0.600
#5	Device 1	1,125.90'	6.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=3.84 cfs @ 12.09 hrs HW=1,123.19' (Free Discharge)

- 1=Culvert (Passes 3.84 cfs of 6.05 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.09 cfs @ 9.79 fps)
- 3=Orifice/Grate (Orifice Controls 3.44 cfs @ 6.31 fps)
- 4=Orifice/Grate (Orifice Controls 0.30 cfs @ 1.82 fps)
- 5=Broad-Crested Rectangular Weir(Controls 0.00 cfs)

Pond 3P: UNDERGROUND STORAGE - Chamber Wizard Field A

Chamber Model = CMP Round 84 (Round Corrugated Metal Pipe)

Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf

Overall Size= 84.0"W x 84.0"H x 20.00'L

Row Length Adjustment= -7.00' x 38.48 sf x 4 rows

84.0" Wide + 36.0" Spacing = 120.0" C-C Row Spacing

4 Chambers/Row x 20.00' Long -7.00' Row Adjustment +7.00' Header x 1 = 80.00' Row Length +12.0" End Stone x 2 = 82.00' Base Length

4 Rows x 84.0" Wide + 36.0" Spacing x 3 + 12.0" Side Stone x 2 = 39.00' Base Width

84.0" Chamber Height + 6.0" Cover = 7.50' Field Height

16 Chambers x 769.7 cf -7.00' Row Adjustment x 38.48 sf x 4 Rows + 37.00' Header x 38.48 sf =
12,661.4 cf Chamber Storage

23,985.0 cf Field - 12,661.4 cf Chambers = 11,323.6 cf Stone x 40.0% Voids = 4,529.4 cf Stone Storage

Chamber Storage + Stone Storage = 17,190.8 cf = 0.395 af

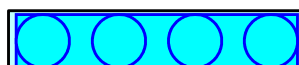
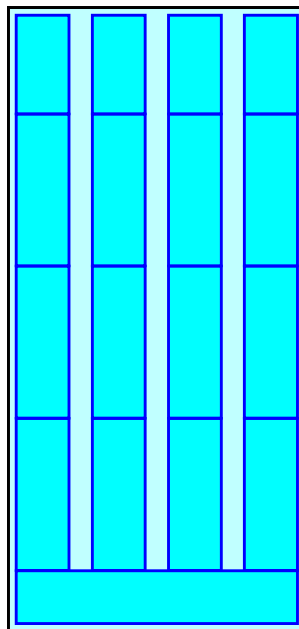
Overall Storage Efficiency = 71.7%

Overall System Size = 82.00' x 39.00' x 7.50'

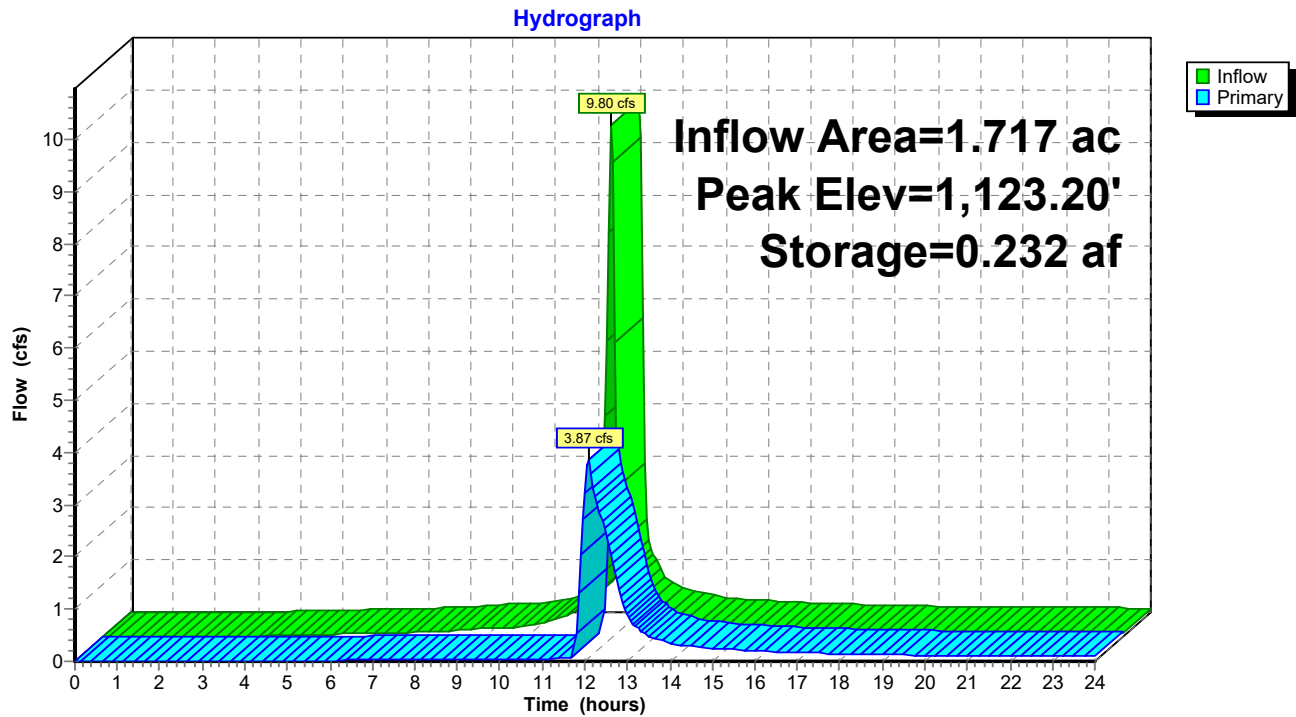
16 Chambers

888.3 cy Field

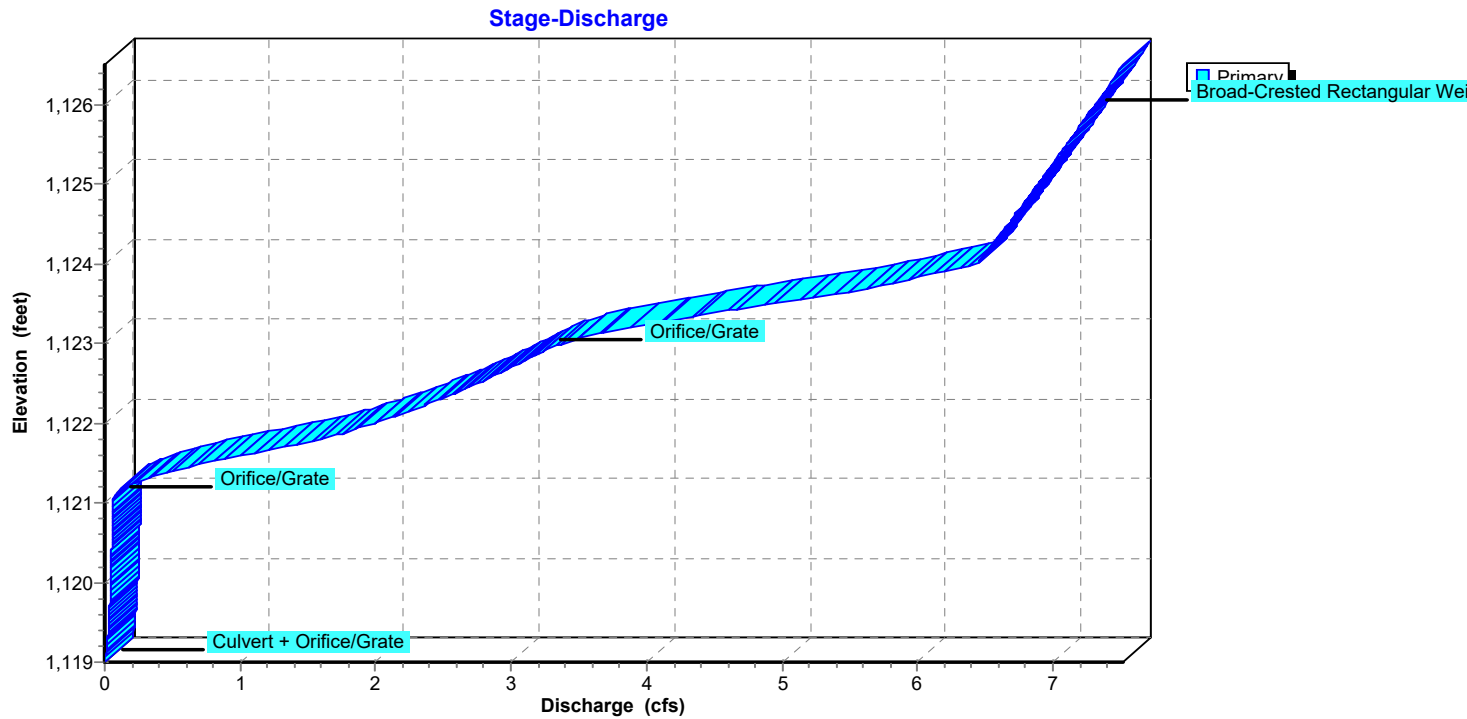
419.4 cy Stone



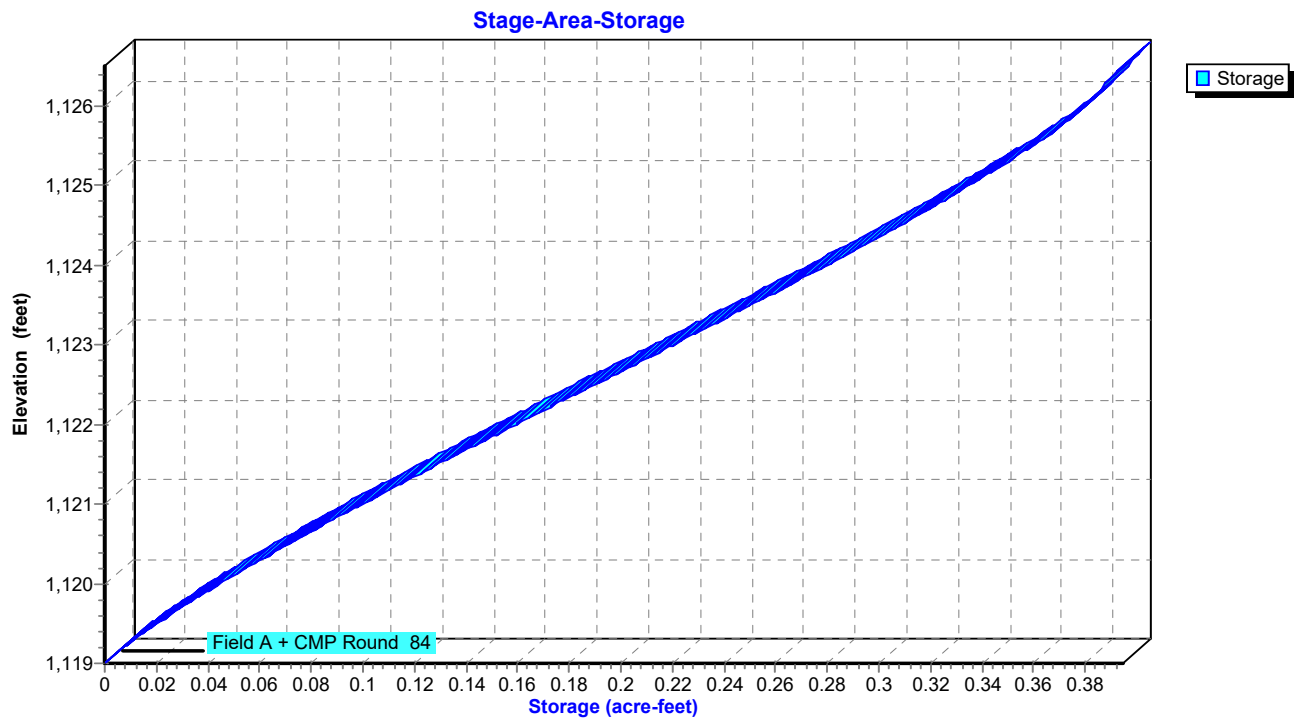
Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE

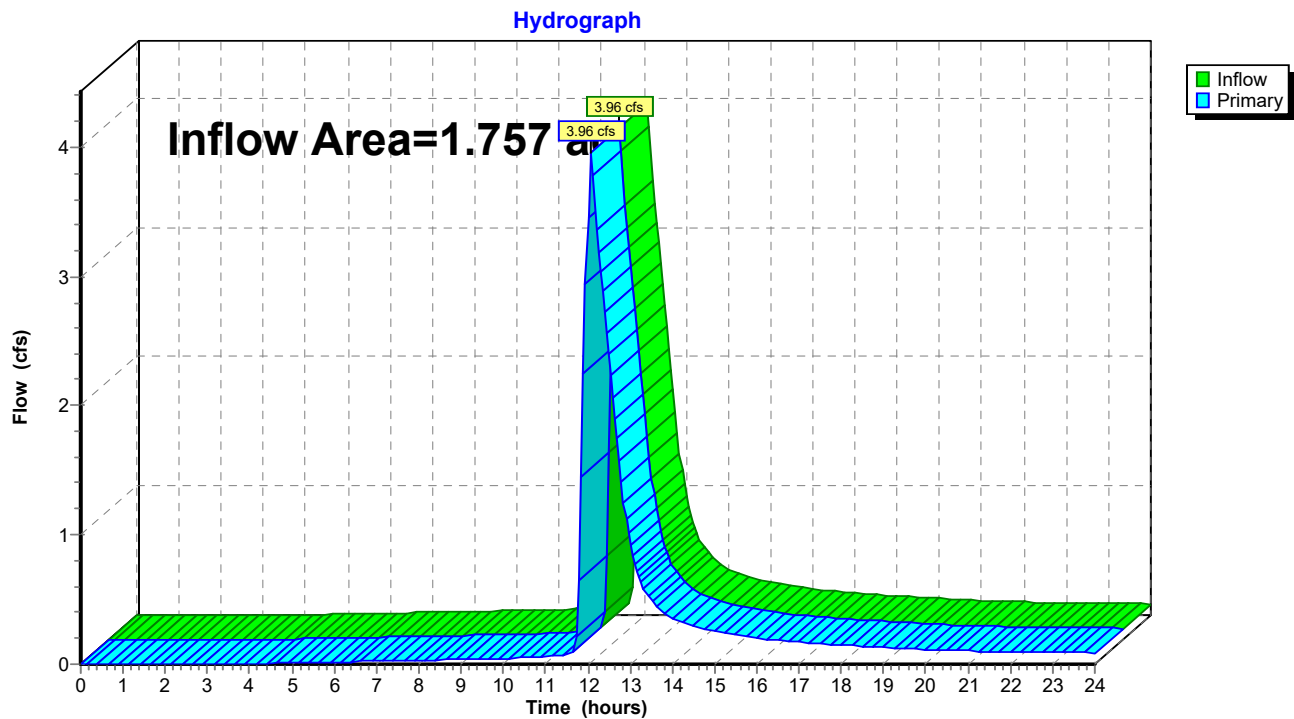


Summary for Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow Area = 1.757 ac, 82.19% Impervious, Inflow Depth > 2.93" for 25 YR event
 Inflow = 3.96 cfs @ 12.08 hrs, Volume= 0.429 af
 Primary = 3.96 cfs @ 12.08 hrs, Volume= 0.429 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE



Site TR-55 Final*Type II 24-hr 50 YR Rainfall=5.00"*

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: TOTAL PRE

Runoff Area=1.757 ac 0.00% Impervious Runoff Depth>2.36"
Flow Length=310' Tc=12.1 min CN=74 Runoff=5.88 cfs 0.345 af

Subcatchment2S: POST DEVELOPMENT

Runoff Area=1.717 ac 81.77% Impervious Runoff Depth>4.30"
Tc=6.0 min CN=94 Runoff=11.45 cfs 0.616 af

Subcatchment4S: POST DEVELOPMENT

Runoff Area=0.040 ac 100.00% Impervious Runoff Depth>4.76"
Tc=6.0 min CN=98 Runoff=0.28 cfs 0.016 af

Pond 3P: UNDERGROUND STORAGE

Peak Elev=1,123.66' Storage=0.260 af Inflow=11.45 cfs 0.616 af
Outflow=5.56 cfs 0.508 af

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow=5.69 cfs 0.524 af
Primary=5.69 cfs 0.524 af

Total Runoff Area = 3.514 ac Runoff Volume = 0.977 af Average Runoff Depth = 3.34"
58.91% Pervious = 2.070 ac 41.09% Impervious = 1.444 ac

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Type II 24-hr 50 YR Rainfall=5.00"

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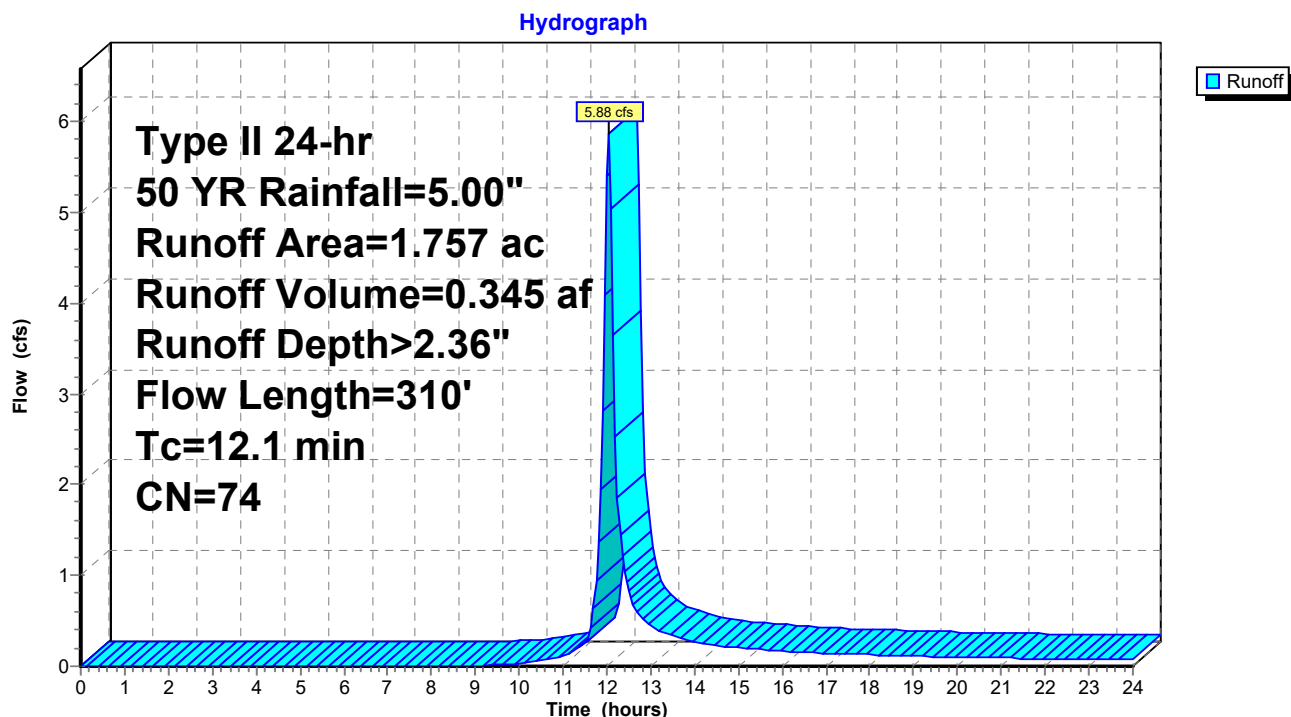
Summary for Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

Runoff = 5.88 cfs @ 12.04 hrs, Volume= 0.345 af, Depth> 2.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 50 YR Rainfall=5.00"

Area (ac)	CN	Description
* 1.757	74	Existing Lawn Area
1.757		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	100	0.0200	0.15		Sheet Flow, Sheet Flow Grass: Short n= 0.150 P2= 2.44"
0.3	95	0.1100	5.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
0.6	115	0.0430	3.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
12.1	310	Total			

Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

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Type II 24-hr 50 YR Rainfall=5.00"

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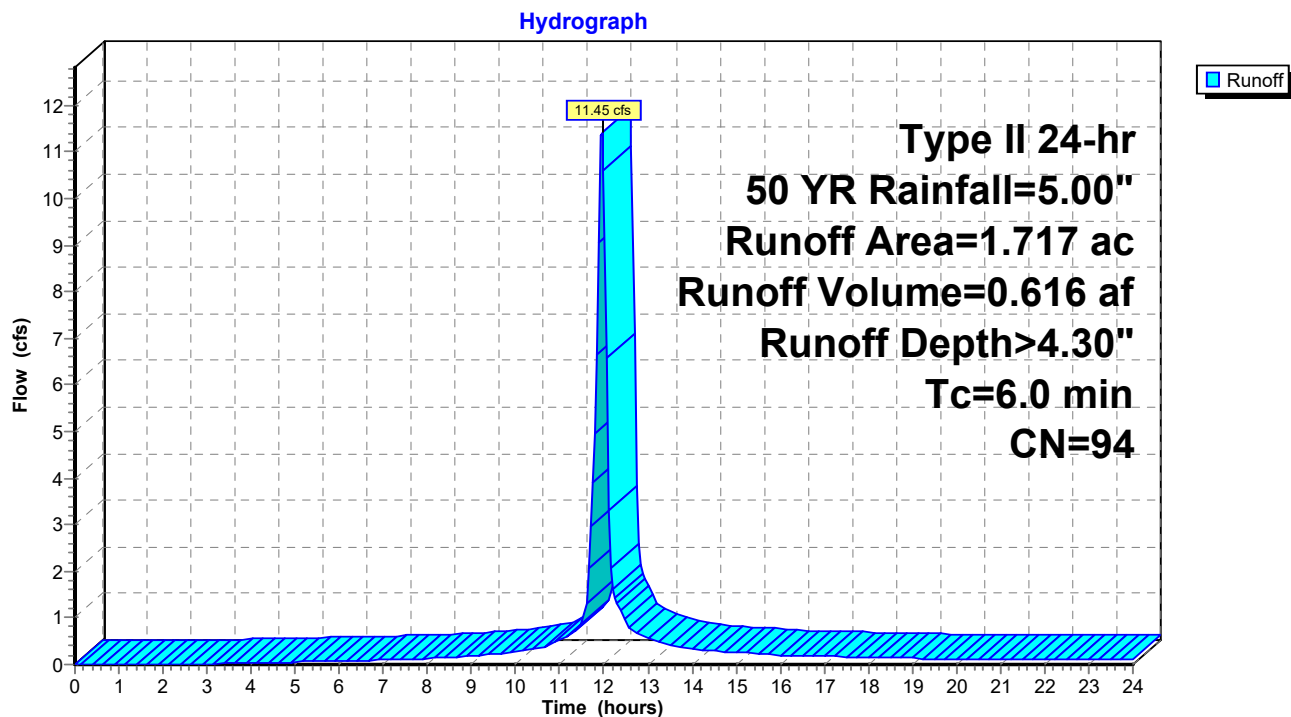
Summary for Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

Runoff = 11.45 cfs @ 11.96 hrs, Volume= 0.616 af, Depth> 4.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 50 YR Rainfall=5.00"

	Area (ac)	CN	Description
*	1.404	98	Impervious
*	0.313	74	Open
	1.717	94	Weighted Average
	0.313		18.23% Pervious Area
	1.404		81.77% Impervious Area

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

Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

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Type II 24-hr 50 YR Rainfall=5.00"

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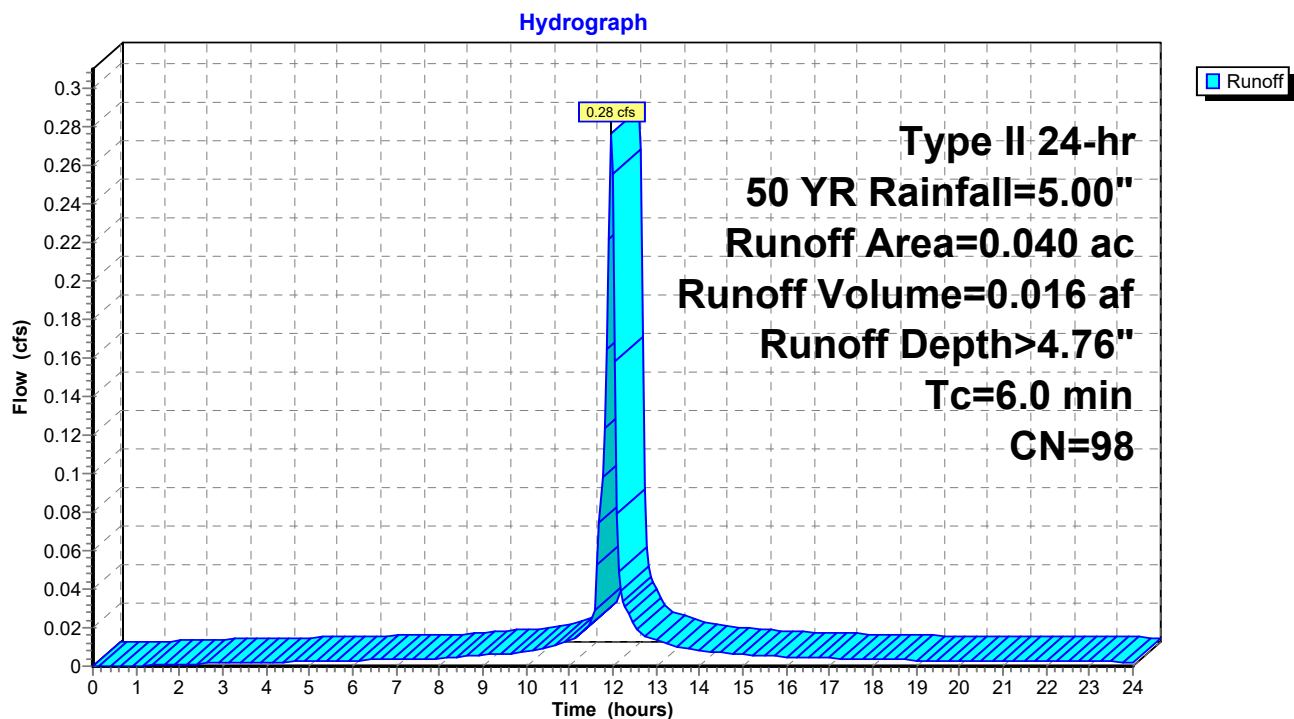
Summary for Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Runoff = 0.28 cfs @ 11.96 hrs, Volume= 0.016 af, Depth> 4.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 50 YR Rainfall=5.00"

Area (ac)	CN	Description
* 0.040	98	Impervious
0.040		100.00% Impervious Area

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

Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Summary for Pond 3P: UNDERGROUND STORAGE

Inflow Area = 1.717 ac, 81.77% Impervious, Inflow Depth > 4.30" for 50 YR event
 Inflow = 11.45 cfs @ 11.96 hrs, Volume= 0.616 af
 Outflow = 5.56 cfs @ 12.07 hrs, Volume= 0.508 af, Atten= 51%, Lag= 6.4 min
 Primary = 5.56 cfs @ 12.07 hrs, Volume= 0.508 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,123.66' @ 12.07 hrs Surf.Area= 0.073 ac Storage= 0.260 af

Plug-Flow detention time= 133.2 min calculated for 0.507 af (82% of inflow)
 Center-of-Mass det. time= 60.1 min (829.5 - 769.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	1,119.00'	0.104 af	39.00'W x 82.00'L x 7.50'H Field A 0.551 af Overall - 0.291 af Embedded = 0.260 af x 40.0% Voids
#2A	1,119.00'	0.291 af	CMP Round 84 x 16 Inside #1 Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf Overall Size= 84.0"W x 84.0"H x 20.00'L Row Length Adjustment= -7.00' x 38.48 sf x 4 rows 37.00' Header x 38.48 sf x 1 = 1,423.9 cf Inside
			0.395 af Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	1,119.00'	12.0" Round Culvert L= 191.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,119.00' / 1,116.10' S= 0.0152 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	1,119.00'	1.3" Vert. Orifice/Grate C= 0.600
#3	Device 1	1,121.05'	10.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	1,122.90'	10.0" Vert. Orifice/Grate C= 0.600
#5	Device 1	1,125.90'	6.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=5.44 cfs @ 12.07 hrs HW=1,123.63' (Free Discharge)

- 1=Culvert (Passes 5.44 cfs of 6.27 cfs potential flow)
- 2=Orifice/Grate (Orifice Controls 0.09 cfs @ 10.30 fps)
- 3=Orifice/Grate (Orifice Controls 3.86 cfs @ 7.08 fps)
- 4=Orifice/Grate (Orifice Controls 1.48 cfs @ 2.91 fps)
- 5=Broad-Crested Rectangular Weir(Controls 0.00 cfs)

Pond 3P: UNDERGROUND STORAGE - Chamber Wizard Field A**Chamber Model = CMP Round 84 (Round Corrugated Metal Pipe)**

Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf

Overall Size= 84.0"W x 84.0"H x 20.00'L

Row Length Adjustment= -7.00' x 38.48 sf x 4 rows

84.0" Wide + 36.0" Spacing = 120.0" C-C Row Spacing

4 Chambers/Row x 20.00' Long -7.00' Row Adjustment +7.00' Header x 1 = 80.00' Row Length +12.0" End Stone x 2 = 82.00' Base Length

4 Rows x 84.0" Wide + 36.0" Spacing x 3 + 12.0" Side Stone x 2 = 39.00' Base Width

84.0" Chamber Height + 6.0" Cover = 7.50' Field Height

16 Chambers x 769.7 cf -7.00' Row Adjustment x 38.48 sf x 4 Rows + 37.00' Header x 38.48 sf =
12,661.4 cf Chamber Storage

23,985.0 cf Field - 12,661.4 cf Chambers = 11,323.6 cf Stone x 40.0% Voids = 4,529.4 cf Stone Storage

Chamber Storage + Stone Storage = 17,190.8 cf = 0.395 af

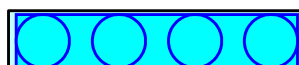
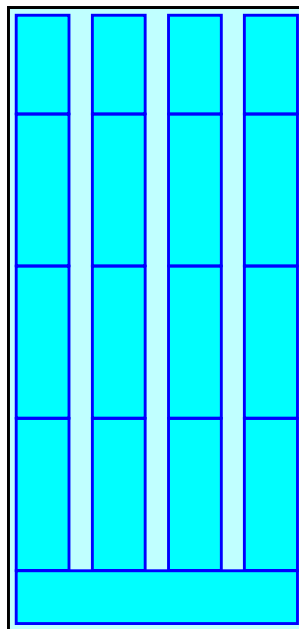
Overall Storage Efficiency = 71.7%

Overall System Size = 82.00' x 39.00' x 7.50'

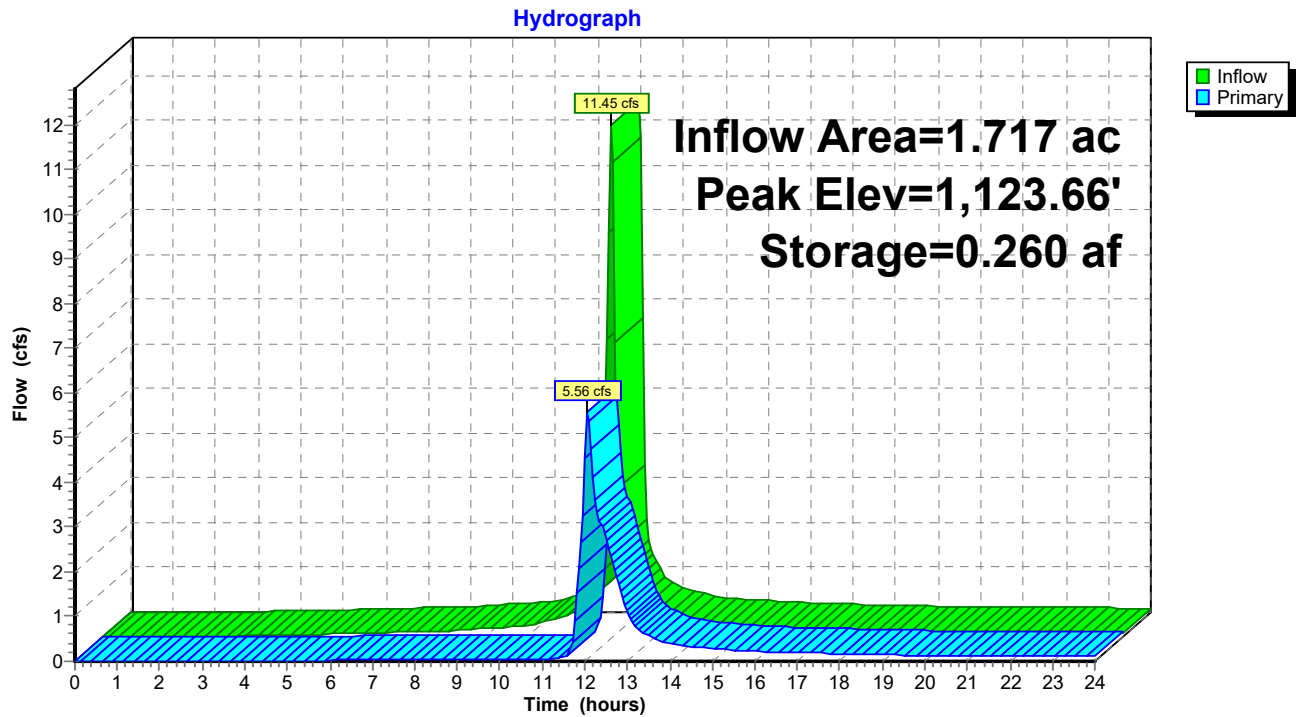
16 Chambers

888.3 cy Field

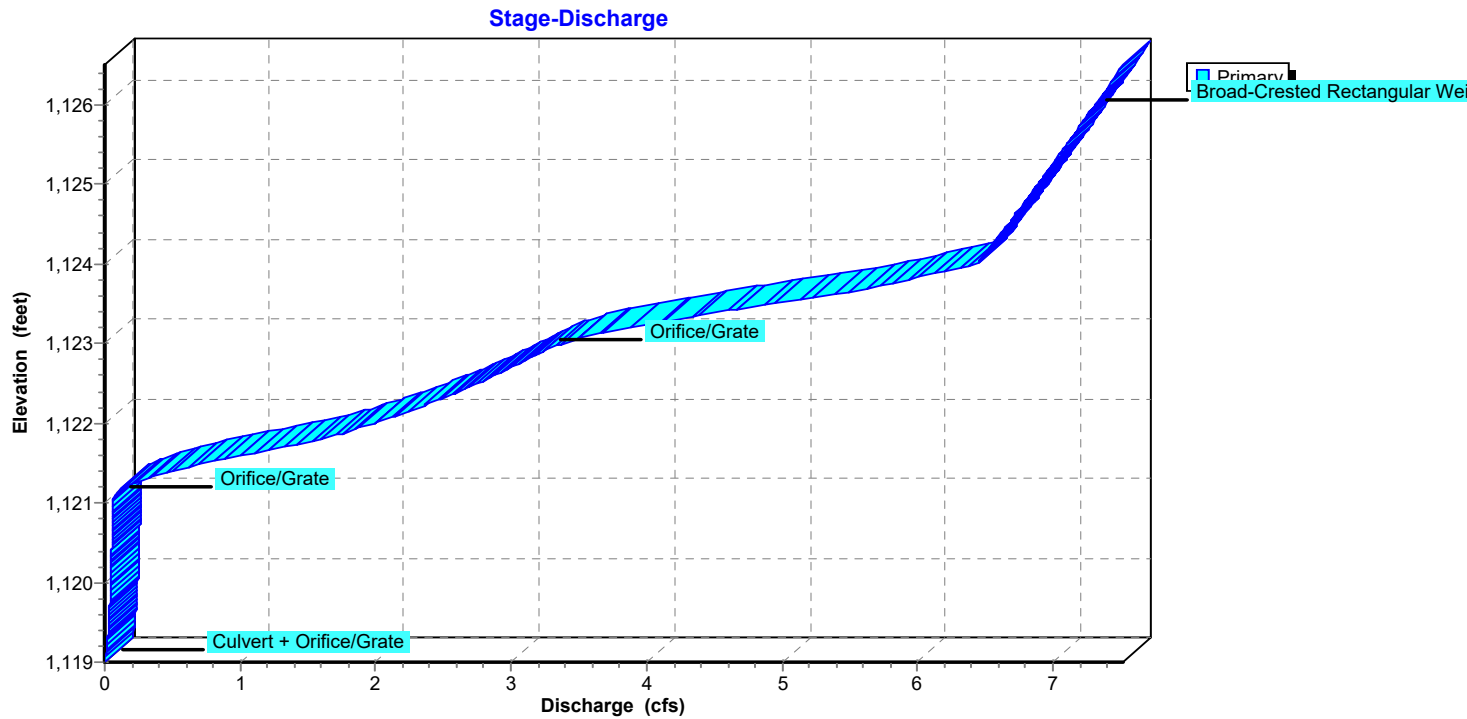
419.4 cy Stone



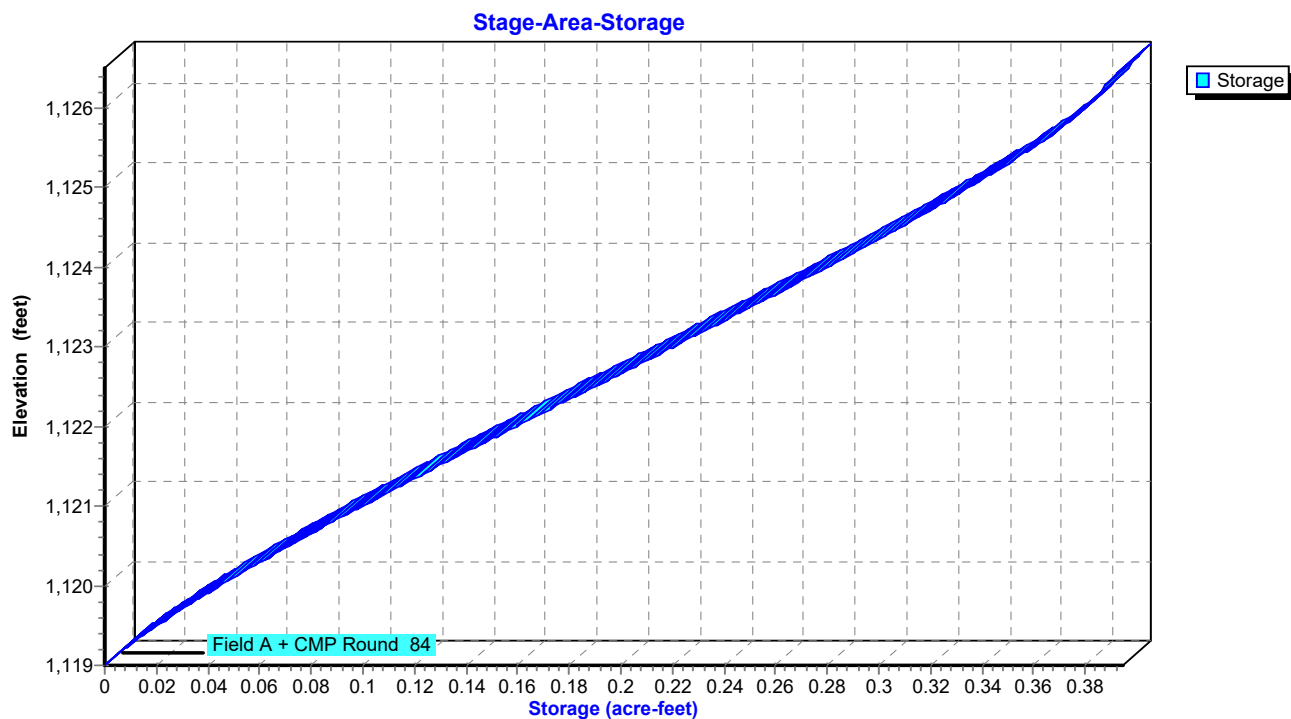
Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE

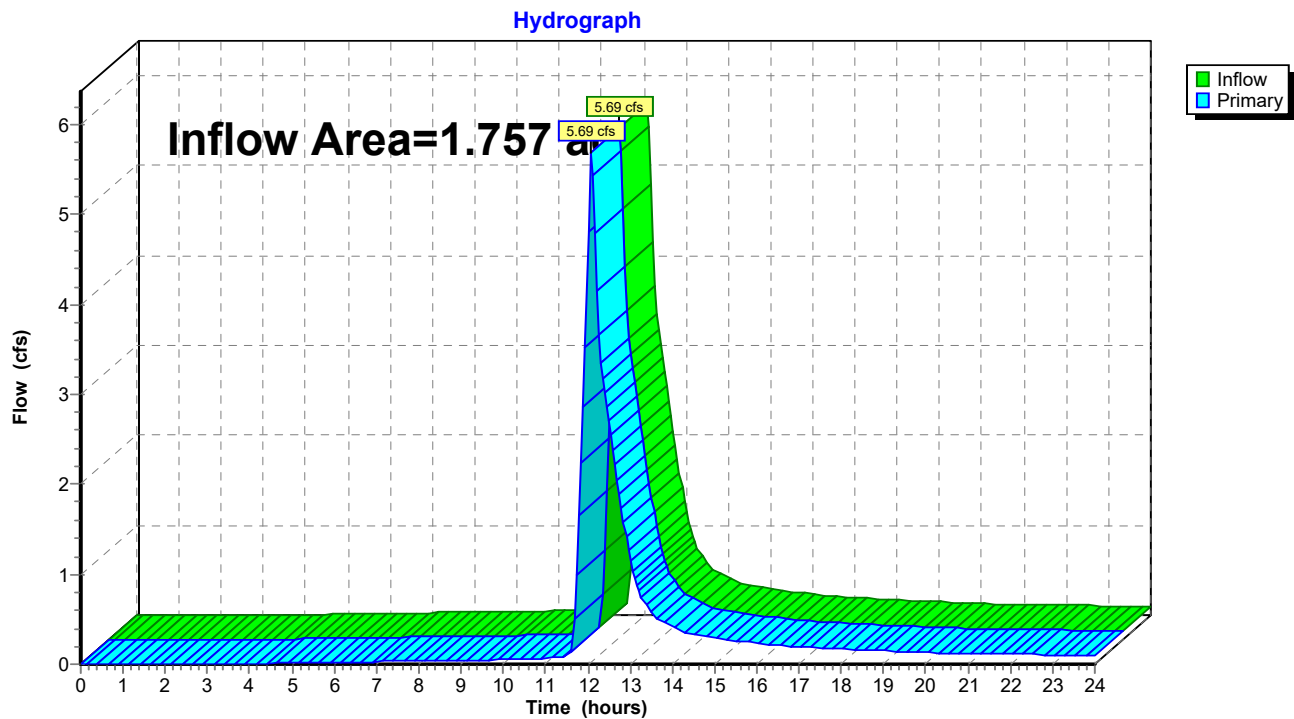


Summary for Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow Area = 1.757 ac, 82.19% Impervious, Inflow Depth > 3.58" for 50 YR event
 Inflow = 5.69 cfs @ 12.07 hrs, Volume= 0.524 af
 Primary = 5.69 cfs @ 12.07 hrs, Volume= 0.524 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE



Site TR-55 Final*Type II 24-hr 100 YR Rainfall=5.73"*

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: TOTAL PRE

Runoff Area=1.757 ac 0.00% Impervious Runoff Depth>2.95"
Flow Length=310' Tc=12.1 min CN=74 Runoff=7.36 cfs 0.432 af

Subcatchment2S: POST DEVELOPMENT

Runoff Area=1.717 ac 81.77% Impervious Runoff Depth>5.03"
Tc=6.0 min CN=94 Runoff=13.24 cfs 0.719 af

Subcatchment4S: POST DEVELOPMENT

Runoff Area=0.040 ac 100.00% Impervious Runoff Depth>5.49"
Tc=6.0 min CN=98 Runoff=0.32 cfs 0.018 af

Pond 3P: UNDERGROUND STORAGE

Peak Elev=1,124.13' Storage=0.287 af Inflow=13.24 cfs 0.719 af
Outflow=6.53 cfs 0.610 af

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow=6.68 cfs 0.628 af
Primary=6.68 cfs 0.628 af

Total Runoff Area = 3.514 ac Runoff Volume = 1.169 af Average Runoff Depth = 3.99"
58.91% Pervious = 2.070 ac 41.09% Impervious = 1.444 ac

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Type II 24-hr 100 YR Rainfall=5.73"

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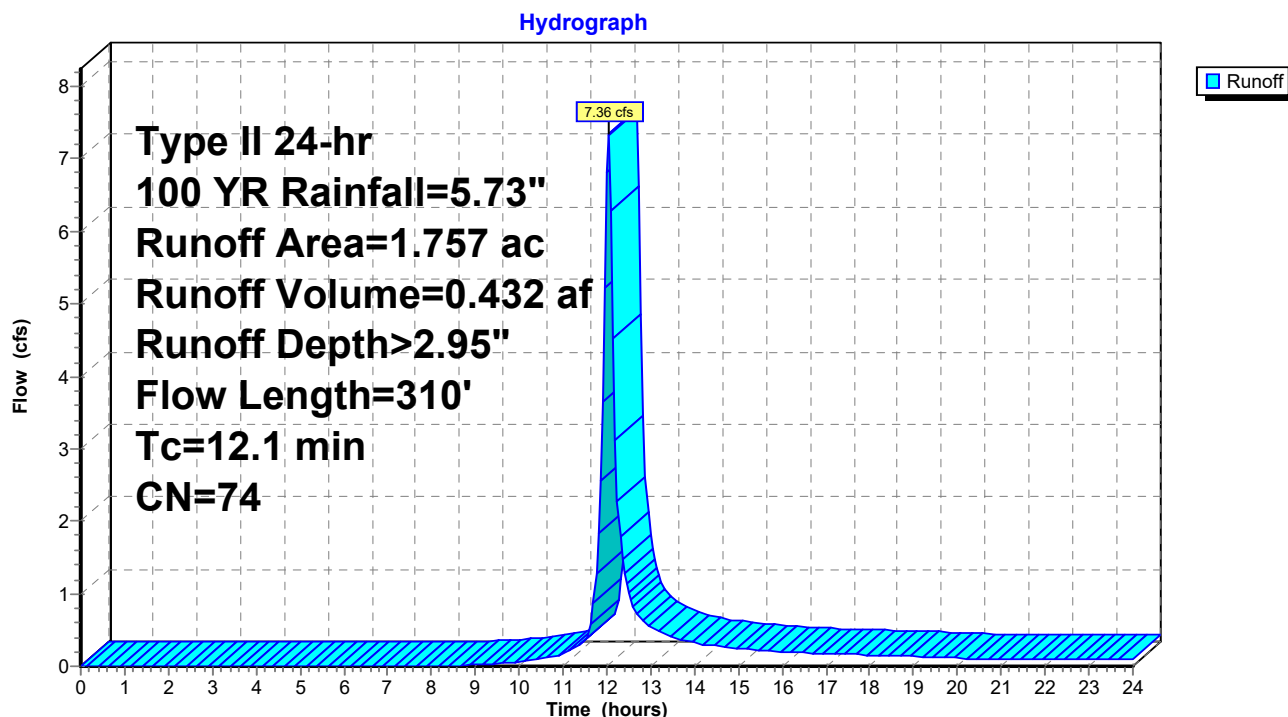
Summary for Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

Runoff = 7.36 cfs @ 12.04 hrs, Volume= 0.432 af, Depth> 2.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 YR Rainfall=5.73"

Area (ac)	CN	Description
* 1.757	74	Existing Lawn Area
1.757		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.2	100	0.0200	0.15		Sheet Flow, Sheet Flow Grass: Short n= 0.150 P2= 2.44"
0.3	95	0.1100	5.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
0.6	115	0.0430	3.34		Shallow Concentrated Flow, Shallow Conc. Flow Unpaved Kv= 16.1 fps
12.1	310	Total			

Subcatchment 1S: TOTAL PRE DEVELOPMENT DRAINAGE AREA

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Type II 24-hr 100 YR Rainfall=5.73"

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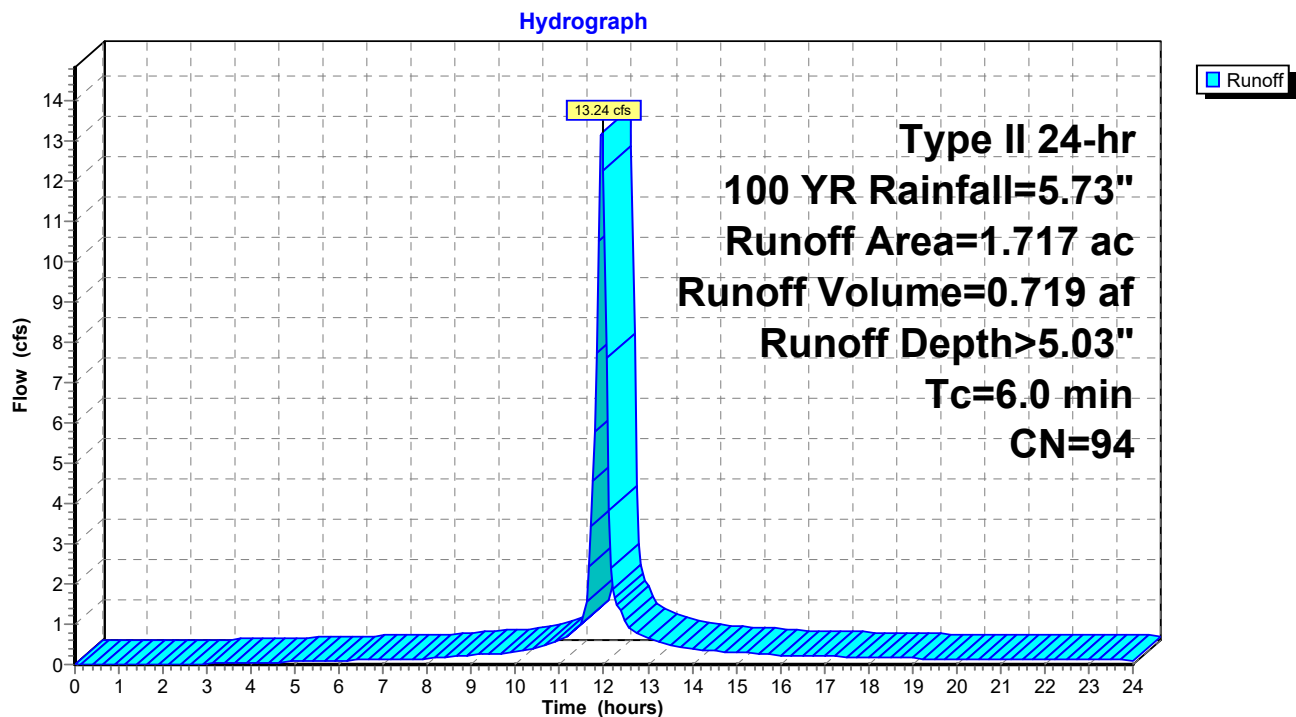
Summary for Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

Runoff = 13.24 cfs @ 11.96 hrs, Volume= 0.719 af, Depth> 5.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 YR Rainfall=5.73"

	Area (ac)	CN	Description
*	1.404	98	Impervious
*	0.313	74	Open
	1.717	94	Weighted Average
	0.313		18.23% Pervious Area
	1.404		81.77% Impervious Area

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

Subcatchment 2S: POST DEVELOPMENT DRAINAGE AREA TO UNDERGROUND STORAGE

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Type II 24-hr 100 YR Rainfall=5.73"

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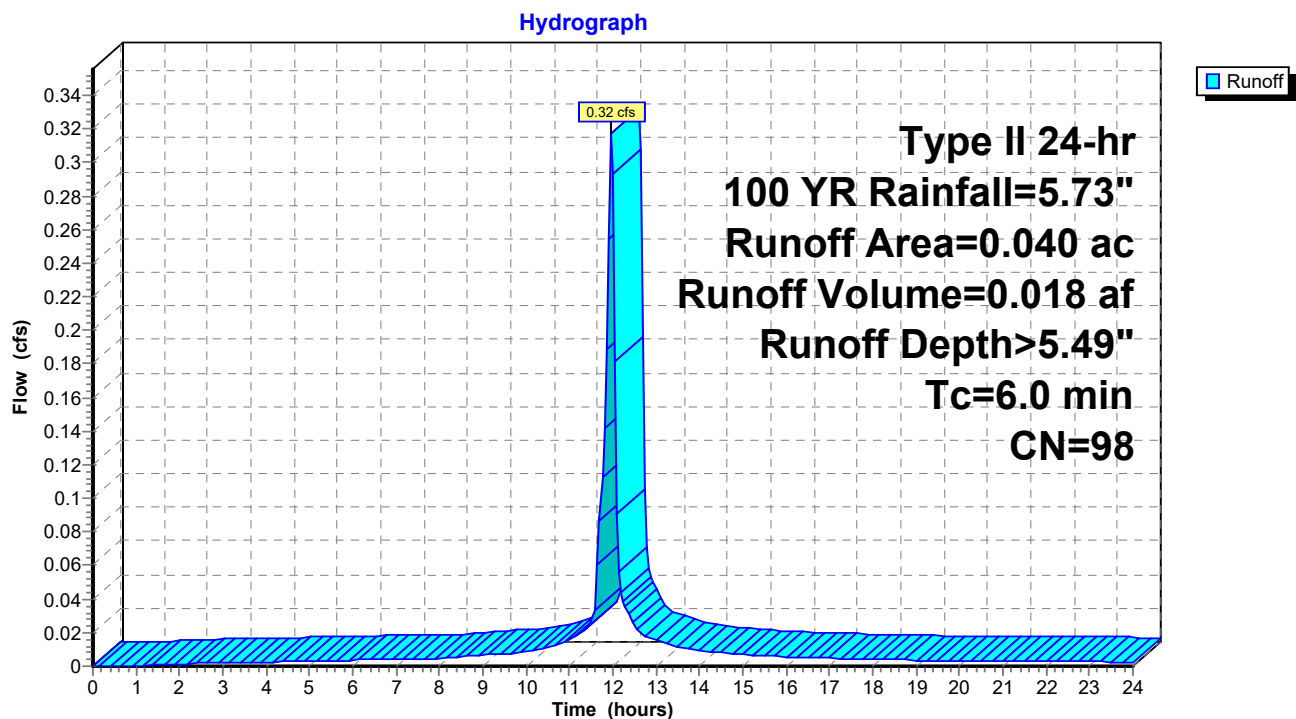
Summary for Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Runoff = 0.32 cfs @ 11.96 hrs, Volume= 0.018 af, Depth> 5.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type II 24-hr 100 YR Rainfall=5.73"

Area (ac)	CN	Description
* 0.040	98	Impervious
0.040		100.00% Impervious Area

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

Subcatchment 4S: POST DEVELOPMENT UNDETAINED PAVEMENT AREA

Summary for Pond 3P: UNDERGROUND STORAGE

Inflow Area = 1.717 ac, 81.77% Impervious, Inflow Depth > 5.03" for 100 YR event
 Inflow = 13.24 cfs @ 11.96 hrs, Volume= 0.719 af
 Outflow = 6.53 cfs @ 12.07 hrs, Volume= 0.610 af, Atten= 51%, Lag= 6.6 min
 Primary = 6.53 cfs @ 12.07 hrs, Volume= 0.610 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Peak Elev= 1,124.13' @ 12.07 hrs Surf.Area= 0.073 ac Storage= 0.287 af

Plug-Flow detention time= 125.6 min calculated for 0.610 af (85% of inflow)
 Center-of-Mass det. time= 57.6 min (823.2 - 765.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	1,119.00'	0.104 af	39.00'W x 82.00'L x 7.50'H Field A 0.551 af Overall - 0.291 af Embedded = 0.260 af x 40.0% Voids
#2A	1,119.00'	0.291 af	CMP Round 84 x 16 Inside #1 Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf Overall Size= 84.0"W x 84.0"H x 20.00'L Row Length Adjustment= -7.00' x 38.48 sf x 4 rows 37.00' Header x 38.48 sf x 1 = 1,423.9 cf Inside
0.395 af			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	1,119.00'	12.0" Round Culvert L= 191.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,119.00' / 1,116.10' S= 0.0152 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	1,119.00'	1.3" Vert. Orifice/Grate C= 0.600
#3	Device 1	1,121.05'	10.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	1,122.90'	10.0" Vert. Orifice/Grate C= 0.600
#5	Device 1	1,125.90'	6.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=6.48 cfs @ 12.07 hrs HW=1,124.09' (Free Discharge)

- 1=Culvert (Barrel Controls 6.48 cfs @ 8.25 fps)
- 2=Orifice/Grate (Passes < 0.10 cfs potential flow)
- 3=Orifice/Grate (Passes < 4.25 cfs potential flow)
- 4=Orifice/Grate (Passes < 2.30 cfs potential flow)
- 5=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 3P: UNDERGROUND STORAGE - Chamber Wizard Field A**Chamber Model = CMP Round 84 (Round Corrugated Metal Pipe)**

Effective Size= 84.0"W x 84.0"H => 38.48 sf x 20.00'L = 769.7 cf

Overall Size= 84.0"W x 84.0"H x 20.00'L

Row Length Adjustment= -7.00' x 38.48 sf x 4 rows

84.0" Wide + 36.0" Spacing = 120.0" C-C Row Spacing

4 Chambers/Row x 20.00' Long -7.00' Row Adjustment +7.00' Header x 1 = 80.00' Row Length +12.0" End Stone x 2 = 82.00' Base Length

4 Rows x 84.0" Wide + 36.0" Spacing x 3 + 12.0" Side Stone x 2 = 39.00' Base Width

84.0" Chamber Height + 6.0" Cover = 7.50' Field Height

16 Chambers x 769.7 cf -7.00' Row Adjustment x 38.48 sf x 4 Rows + 37.00' Header x 38.48 sf =
12,661.4 cf Chamber Storage

23,985.0 cf Field - 12,661.4 cf Chambers = 11,323.6 cf Stone x 40.0% Voids = 4,529.4 cf Stone Storage

Chamber Storage + Stone Storage = 17,190.8 cf = 0.395 af

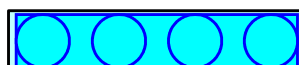
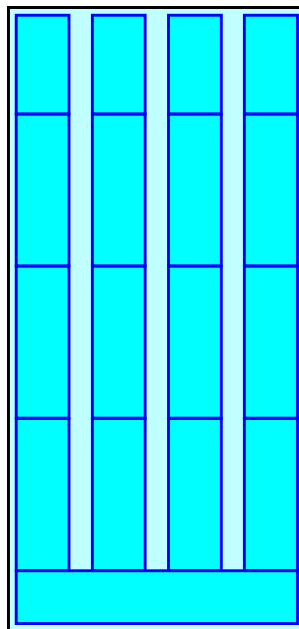
Overall Storage Efficiency = 71.7%

Overall System Size = 82.00' x 39.00' x 7.50'

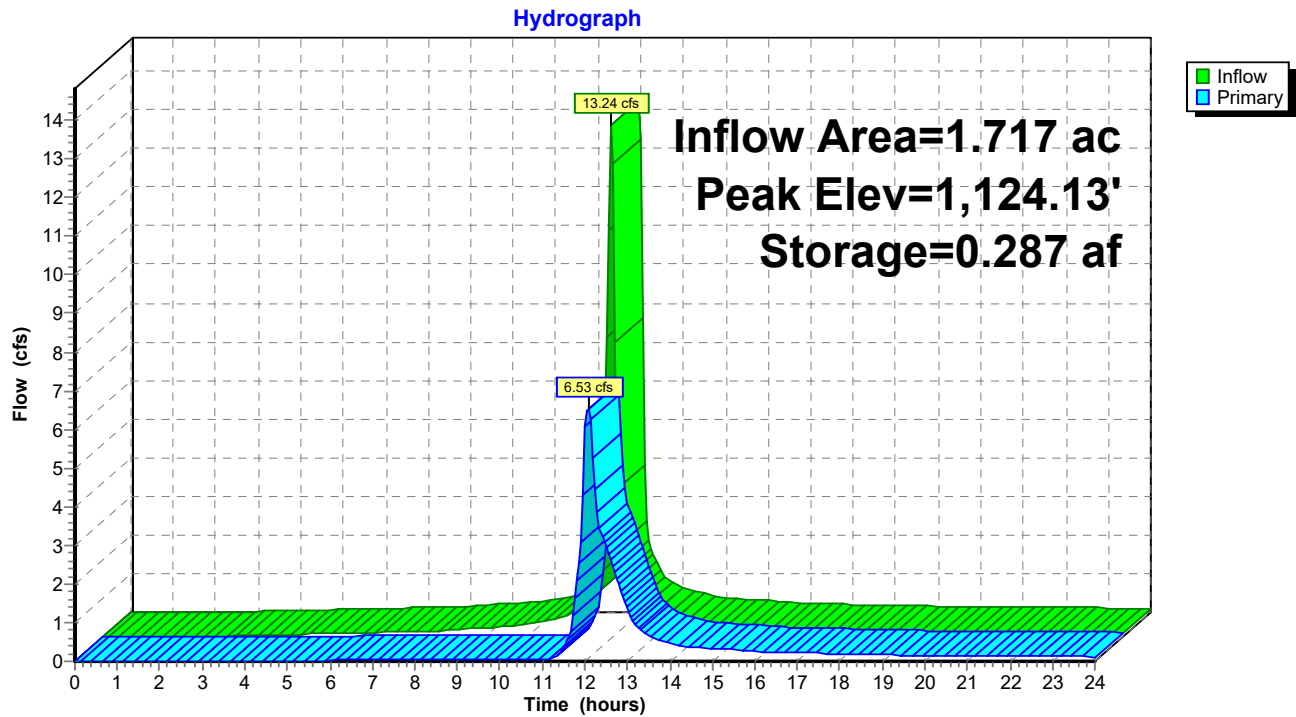
16 Chambers

888.3 cy Field

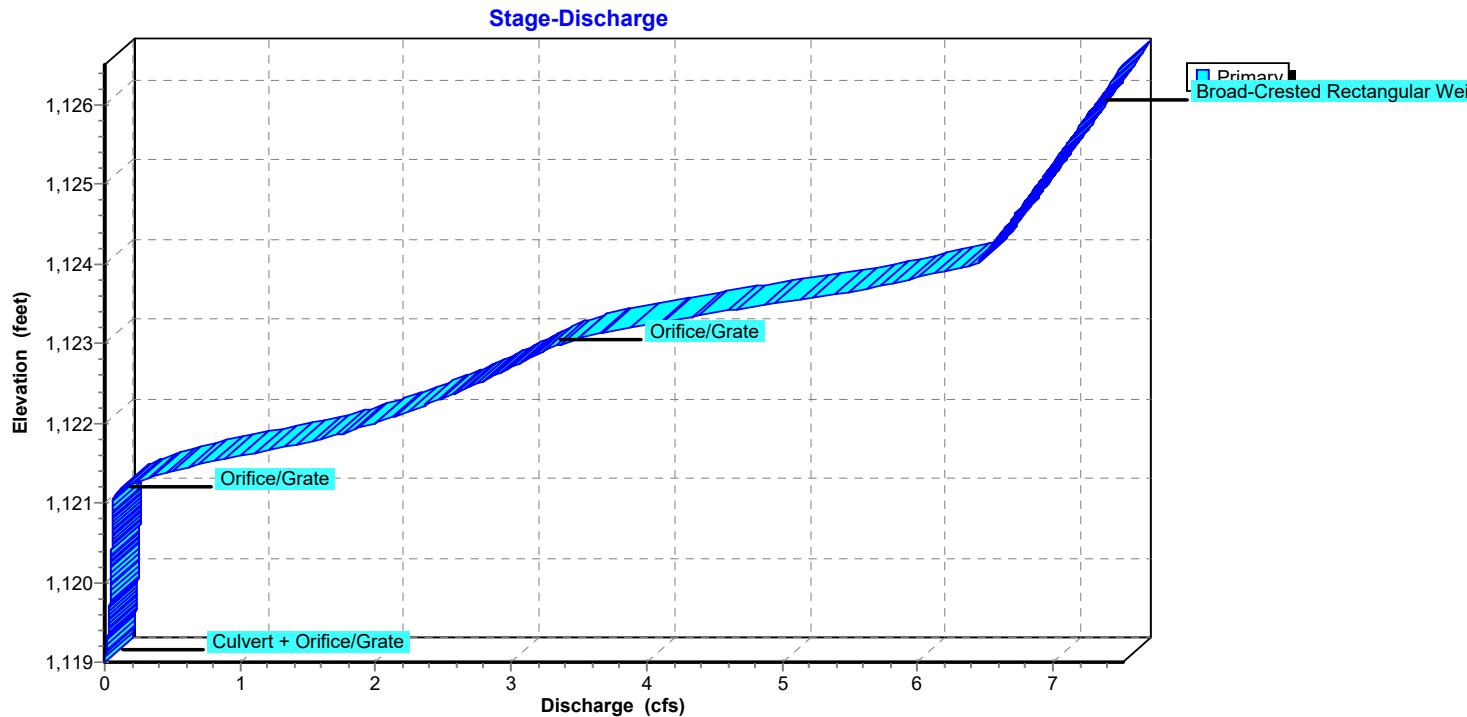
419.4 cy Stone



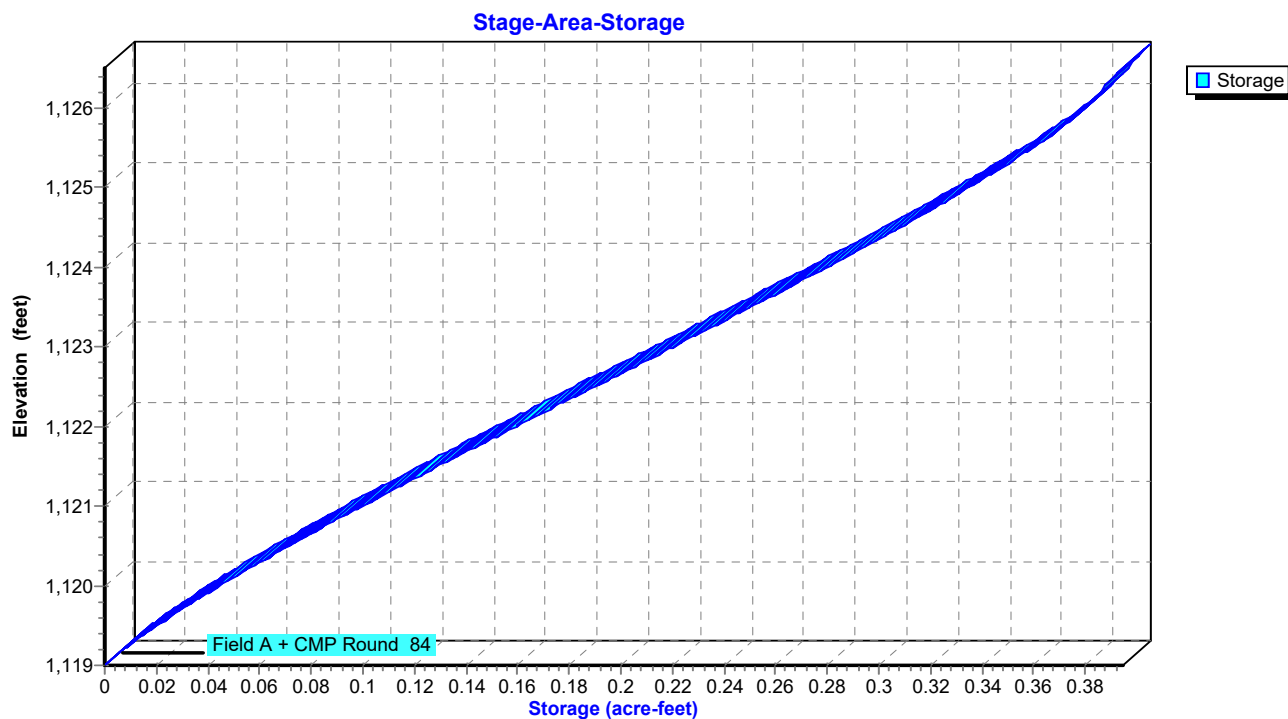
Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE



Pond 3P: UNDERGROUND STORAGE

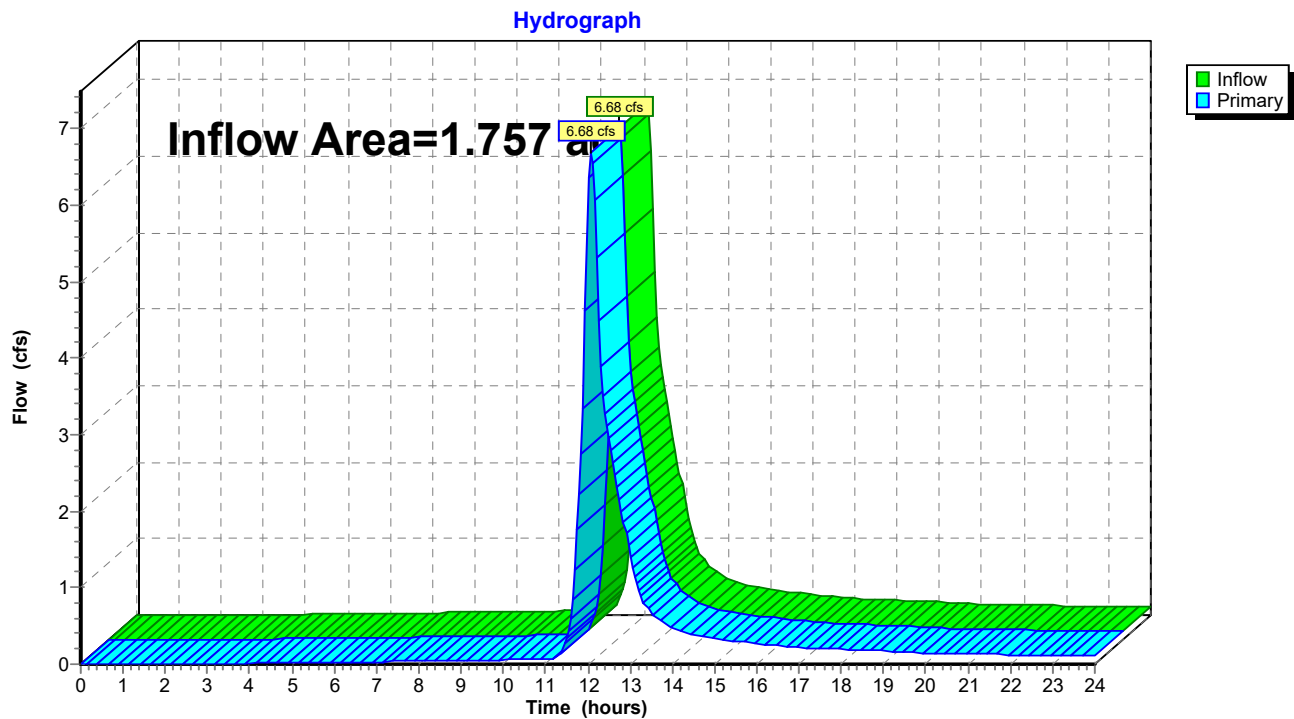


Summary for Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE

Inflow Area = 1.757 ac, 82.19% Impervious, Inflow Depth > 4.29" for 100 YR event
 Inflow = 6.68 cfs @ 12.06 hrs, Volume= 0.628 af
 Primary = 6.68 cfs @ 12.06 hrs, Volume= 0.628 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 5L: TOTAL POST DEVELOPMENT RELEASE RATE



Appendix D: Soil Information

Hydrologic Soil Group—Stark County, Ohio



MAP LEGEND

Area of Interest (AOI)









 Area of Interest (AOI)

Soils

Soil Rating Polygons

 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Lines

 A
 A/D
 B
 B/D
 C
 C/D
 D
 Not rated or not available

Soil Rating Points

 A
 A/D
 B
 B/D

 C
 C/D
 D
 Not rated or not available

Water Features

 Streams and Canals

Transportation

 Rails
 Interstate Highways
 US Routes
 Major Roads
 Local Roads

Background

 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

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

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

Soil Survey Area: Stark County, Ohio
 Survey Area Data: Version 19, Sep 12, 2022

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

Date(s) aerial images were photographed: Jul 15, 2020—Aug 21, 2020

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
CeB	Canfield-Urban land complex, 2 to 6 percent slopes	C/D	3.7	98.8%
CeC	Canfield-Urban land complex, 6 to 12 percent slopes	C/D	0.0	1.2%
Totals for Area of Interest			3.7	100.0%

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix E: WQv/WQf Calculations

Site TR-55 Final

Type II 24-hr 100 YR Rainfall=5.73"

Prepared by {enter your company name here}

Printed 3/23/2023

HydroCAD® 10.00-21 s/n 01178 © 2018 HydroCAD Software Solutions LLC

Stage-Area-Storage for Pond 3P: UNDERGROUND STORAGE

Elevation (feet)	Storage (acre-feet)	Elevation (feet)	Storage (acre-feet)
1,119.00	0.000	1,124.20	0.292
1,119.10	0.003	1,124.30	0.297
1,119.20	0.007	1,124.40	0.303
1,119.30	0.011	1,124.50	0.309
1,119.40	0.016	1,124.60	0.314
1,119.50	0.020	1,124.70	0.319
1,119.60	0.025	1,124.80	0.325
1,119.70	0.030	1,124.90	0.330
1,119.80	0.035	1,125.00	0.335
1,119.90	0.040	1,125.10	0.340
1,120.00	0.045	1,125.20	0.345
1,120.10	0.050	1,125.30	0.350
1,120.20	0.055	1,125.40	0.355
1,120.30	0.061	1,125.50	0.360
1,120.40	0.066	1,125.60	0.364
1,120.50	0.071	1,125.70	0.369
1,120.60	0.077	1,125.80	0.373
1,120.70	0.083	1,125.90	0.377
1,120.80	0.088	1,126.00	0.380
1,120.90	0.094	1,126.10	0.383
1,121.00	0.100	1,126.20	0.386
1,121.10	0.106	1,126.30	0.389
1,121.20	0.112	1,126.40	0.392
1,121.30	0.117	1,126.50	0.395
1,121.40	0.123		
1,121.50	0.129		
1,121.60	0.135		
1,121.70	0.141		
1,121.80	0.147		
1,121.90	0.153		
1,122.00	0.159		
1,122.10	0.166		
1,122.20	0.172		
1,122.30	0.178		
1,122.40	0.184		
1,122.50	0.190		
1,122.60	0.196		
1,122.70	0.202		
1,122.80	0.208		
1,122.90	0.214		
1,123.00	0.220		
1,123.10	0.227		
1,123.20	0.233		
1,123.30	0.239		
1,123.40	0.245		
1,123.50	0.251		
1,123.60	0.257		
1,123.70	0.263		
1,123.80	0.268		
1,123.90	0.274		
1,124.00	0.280		
1,124.10	0.286		

WQv Elevation =
1121.05

WQv Calculation

$$WQv = [P * Rv * A] / 12$$

P = average rainfall in inches	0.90 inches
I = Percent impervious	0.82
Rv = volumetric runoff coefficient (0.05+0.9I)	0.79
A = total area draining into the BMP	1.72 ac

WQv =	0.1015 ac-ft
	4,420 cu ft

Average Release Rate of WQv

$$Q_{WQ_avg} = WQv / t_{WQ} = \text{Average release rate of the WQv}$$

t _{WQ} = the intended WQv detention time (24 hrs)	86400 seconds
WQv =	4,420 cu ft
Q _{WQ_avg} =	0.05 cfs

Average Hydraulic Head on Water Quality Outlet

$$h_{wq_avg} = [E_{WQ} - E_{invert}] / 2 = \text{average head on the water quality outlet}$$

E _{WQ} = Elevation with the WQv dropped into system	1121.05 ft
E _{invert} = Invert Elevation of System	1119 ft
h _{wq_total} = Total head on water quality outlet	2.05 ft
h _{wq_avg} =	1.02 ft

Orifice Sizing Equation

$$Q_{WQ_avg} = C * A_{WQ} * \text{SQRT}(2 * g * h_{wq_avg})$$

Q _{WQ_avg} = average release rate of the WQv	0.0512 cfs
C = orifice coefficient	0.60
g = gravitational acceleration	32.20 ft/sec^2
h _{WQ_avg} = average head on the water quality outlet	1.02 ft
A _{WQ} = required orifice area	0.01 ft^2
d _{WQ} = orifice diameter	0.12 ft
	1.39 in

Actual Release Rate - Verification

$$Q_{WQ} = C * A_{WQ} * \text{SQRT}(2 * g * h_{wq_avg})$$

Q _{WQ} = actual release rate of the WQv	0.0449 cfs
C = orifice coefficient	0.6
g = gravitational acceleration	32.20 ft/sec^2
h _{WQ_avg} = average head on the water quality outlet	1.02 ft
A = actual orifice area used	0.0092 ft
d _{WQ} = orifice diameter	1.3 in

Volume Released @ 24 hr	3882 cu-ft	<	4420 cu-ft
Volume Released @ 8 hr	1294 cu-ft	<	2210 cu-ft

WQf Calculation

$$WQf = CiA$$

C = rational method runoff coefficient for drainage area 0.80

$$(1.404*0.95)+(0.313*0.15)/(1.404+0.313)$$

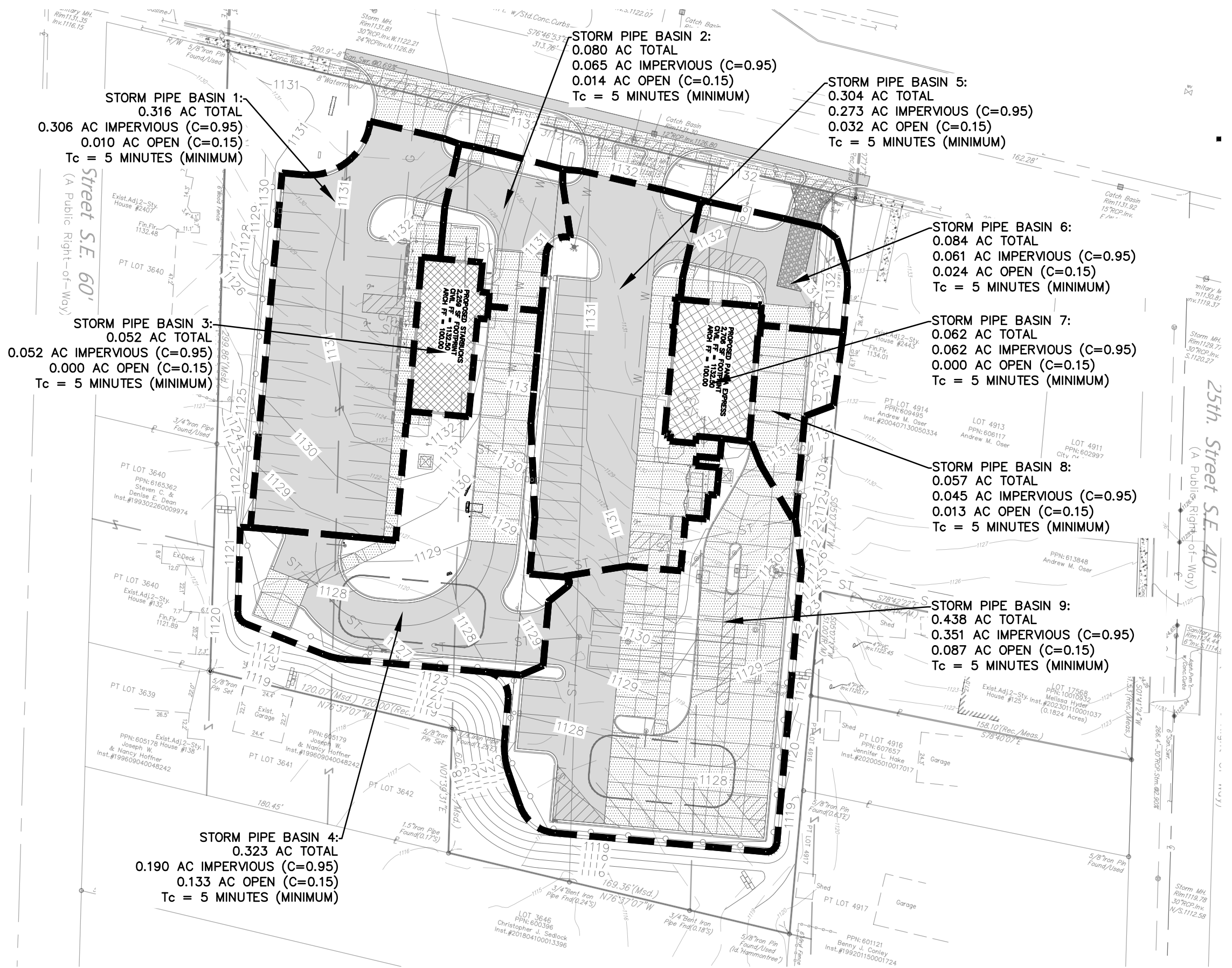
i= intensity per general permit App. C 2.37 in/hr

A = total area draining into the BMP 1.72 ac

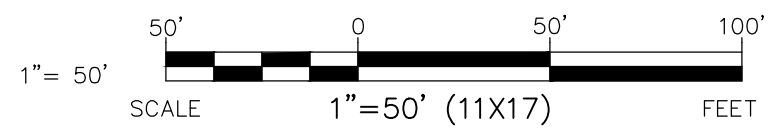
$$WQf = 3.27 \text{ cfs}$$

Contech CS-6 Hydrodynamic Separator Required

Appendix F: Storm Sewer Calculations



STORM SEWER BASIN MAP



Excel Engineering Project No.

2178020

Project Name

Starbucks/Panda Development

Pipe Data				Pipe Capacity (100-yr)				
Pipe Letter	Diameter (FT)	Slope (FT/FT)	Manning's n	Contributing Basin No.	Total Flow (cfs)	Total Flow (gpm)	Full Flow Capacity (cfs)	Full Flow Capacity (gpm)
A	0.67	0.0256	0.012	2,3	0.99	444	2.13	955
B	1	0.0216	0.012	2,3,5,6,7,8	4.72	2118	5.69	2553
C	0.83	0.0150	0.012	1	2.54	1141	2.88	1294
D	1	0.0150	0.012	1,4	4.29	1924	4.74	2127
E	1	0.0155	0.012	9	3.02	1355	4.82	2162
F1	0.5	0.0198	0.012	7 - HALF	0.26	115	0.86	385
F2	0.5	0.0373	0.012	7 - HALF	0.26	115	1.18	528
G	0.67	0.0165	0.012	6,7	1.05	470	1.71	767
H	0.67	0.0165	0.012	6,7,8	1.43	643	1.71	767
I	1.5	0.0200	0.012	1,2,3,4,5,6,7,8,9	12.02	5397	16.14	7242
J	2	0.0000	0.012	EQUALIZATION PIPE				
K	1.5	0.0147	0.012	DETENTION BASIN OUTLET PIPE; SEE HYDROCAD REPORT				
DS	0.5	0.0100	0.012	3	0.43	193	0.61	274

Pipe Drainage Basins-100-Year Design Storm						
Pipe Basin	Area (sf)	Area (ac)	Avg 'C' Value	Time Concentration (min)	Rainfall Intensity (in/hr)	Peak Flow (cfs)
1	13757	0.316	0.92	5	8.71	2.54
2	3478	0.080	0.81	5	8.71	0.56
3	2259	0.052	0.95	5	8.71	0.43
4	14090	0.323	0.62	5	8.71	1.75
5	13257	0.304	0.87	5	8.71	2.30
6	3670	0.084	0.73	5	8.71	0.53
7	2706	0.062	0.95	5	8.71	0.51
8	2486	0.057	0.77	5	8.71	0.39
9	19073	0.438	0.79	5	8.71	3.02

Full Flow Capacity based on Manning's Equation

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} a$$

Where:

Q = Full Flow Capacity of Pipe (cfs)
n = manning's roughness coefficient
R = hydraulic radius (ft) (D/4)
s = hydraulic gradient, slope (ft/ft)
a = flow area (sq. ft.)

Typical Manning's n

HDPE 0.012
PVC 0.012
Concrete 0.013
CMP 0.024

Note: Total flow calculated via rational method hydrologic calculations for the 100-year storm event. Reference Storm Pipe Basin Map and spreadsheet calculations. Rainfall intensity per NOAA Atlas 14

Appendix G: Rainfall Data



NOAA Atlas 14, Volume 2, Version 3
Location name: Massillon, Ohio, USA*
Latitude: 40.7975°, Longitude: -81.4889°
Elevation: 1129.43 ft**
 * source: ESRI Maps
 ** source: USGS



POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

[PF tabular](#) | [PF graphical](#) | [Maps & aerals](#)

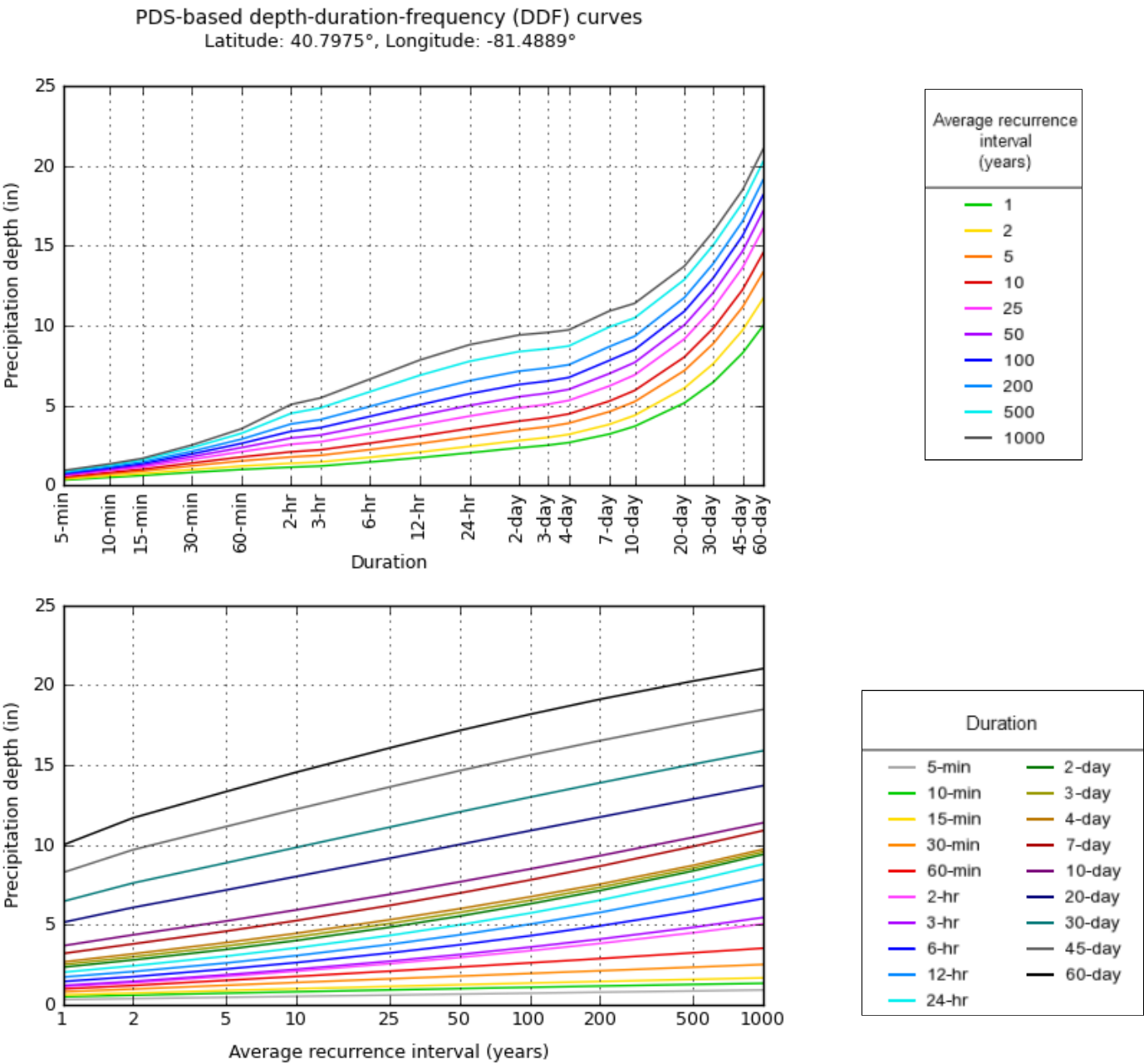
PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.322 (0.294-0.354)	0.385 (0.351-0.421)	0.466 (0.424-0.511)	0.528 (0.480-0.578)	0.607 (0.550-0.664)	0.668 (0.602-0.729)	0.726 (0.652-0.792)	0.786 (0.703-0.857)	0.865 (0.770-0.941)	0.923 (0.817-1.00)
10-min	0.501 (0.458-0.550)	0.601 (0.548-0.658)	0.725 (0.659-0.794)	0.816 (0.741-0.892)	0.929 (0.841-1.02)	1.01 (0.912-1.11)	1.09 (0.982-1.19)	1.17 (1.05-1.28)	1.27 (1.13-1.38)	1.34 (1.19-1.46)
15-min	0.614 (0.561-0.674)	0.734 (0.670-0.804)	0.890 (0.810-0.975)	1.00 (0.911-1.10)	1.15 (1.04-1.25)	1.25 (1.13-1.37)	1.36 (1.22-1.48)	1.46 (1.31-1.59)	1.59 (1.41-1.73)	1.68 (1.49-1.83)
30-min	0.812 (0.742-0.892)	0.983 (0.897-1.08)	1.22 (1.11-1.34)	1.39 (1.26-1.53)	1.62 (1.47-1.77)	1.79 (1.61-1.96)	1.96 (1.76-2.14)	2.13 (1.90-2.32)	2.35 (2.09-2.56)	2.52 (2.23-2.74)
60-min	0.992 (0.906-1.09)	1.21 (1.10-1.32)	1.53 (1.39-1.68)	1.77 (1.61-1.94)	2.10 (1.90-2.30)	2.36 (2.13-2.58)	2.62 (2.35-2.86)	2.89 (2.58-3.15)	3.25 (2.89-3.54)	3.54 (3.13-3.85)
2-hr	1.14 (1.03-1.25)	1.38 (1.25-1.52)	1.78 (1.61-1.96)	2.10 (1.90-2.31)	2.57 (2.31-2.81)	2.96 (2.66-3.24)	3.38 (3.03-3.69)	3.84 (3.42-4.18)	4.50 (3.98-4.89)	5.06 (4.45-5.50)
3-hr	1.21 (1.09-1.34)	1.46 (1.32-1.62)	1.88 (1.70-2.07)	2.22 (2.00-2.45)	2.72 (2.44-2.99)	3.14 (2.81-3.44)	3.61 (3.21-3.94)	4.11 (3.64-4.49)	4.84 (4.25-5.27)	5.46 (4.77-5.94)
6-hr	1.46 (1.32-1.63)	1.76 (1.59-1.96)	2.24 (2.02-2.49)	2.64 (2.38-2.93)	3.24 (2.90-3.59)	3.75 (3.35-4.15)	4.31 (3.83-4.75)	4.94 (4.35-5.43)	5.86 (5.11-6.42)	6.65 (5.75-7.27)
12-hr	1.73 (1.57-1.94)	2.08 (1.89-2.32)	2.61 (2.37-2.92)	3.08 (2.78-3.43)	3.77 (3.38-4.19)	4.37 (3.90-4.84)	5.04 (4.47-5.56)	5.78 (5.09-6.35)	6.88 (6.01-7.55)	7.84 (6.79-8.58)
24-hr	2.03 (1.86-2.24)	2.44 (2.23-2.69)	3.04 (2.77-3.35)	3.56 (3.24-3.91)	4.33 (3.91-4.75)	5.00 (4.49-5.47)	5.73 (5.11-6.27)	6.54 (5.77-7.16)	7.76 (6.74-8.48)	8.80 (7.54-9.62)
2-day	2.35 (2.16-2.58)	2.81 (2.58-3.09)	3.46 (3.18-3.81)	4.02 (3.67-4.41)	4.85 (4.40-5.31)	5.54 (5.00-6.07)	6.31 (5.65-6.91)	7.15 (6.33-7.83)	8.37 (7.31-9.18)	9.41 (8.10-10.3)
3-day	2.51 (2.31-2.75)	3.00 (2.76-3.28)	3.68 (3.38-4.02)	4.24 (3.89-4.63)	5.08 (4.63-5.54)	5.78 (5.23-6.29)	6.53 (5.88-7.12)	7.35 (6.55-8.01)	8.55 (7.52-9.33)	9.57 (8.32-10.5)
4-day	2.68 (2.47-2.91)	3.19 (2.94-3.47)	3.89 (3.59-4.23)	4.47 (4.11-4.85)	5.31 (4.86-5.76)	6.01 (5.46-6.51)	6.75 (6.10-7.33)	7.55 (6.77-8.19)	8.72 (7.74-9.49)	9.73 (8.54-10.6)
7-day	3.21 (2.97-3.47)	3.81 (3.53-4.12)	4.60 (4.26-4.98)	5.26 (4.86-5.69)	6.21 (5.71-6.70)	6.99 (6.39-7.54)	7.81 (7.10-8.42)	8.67 (7.84-9.37)	9.90 (8.86-10.7)	10.9 (9.67-11.8)
10-day	3.69 (3.44-3.97)	4.38 (4.07-4.71)	5.24 (4.87-5.63)	5.93 (5.51-6.38)	6.91 (6.39-7.42)	7.69 (7.08-8.25)	8.49 (7.79-9.12)	9.33 (8.51-10.0)	10.5 (9.48-11.3)	11.4 (10.2-12.3)
20-day	5.15 (4.83-5.50)	6.09 (5.71-6.50)	7.18 (6.72-7.67)	8.03 (7.51-8.57)	9.16 (8.54-9.78)	10.0 (9.33-10.7)	10.9 (10.1-11.6)	11.7 (10.9-12.6)	12.9 (11.8-13.8)	13.7 (12.6-14.7)
30-day	6.46 (6.06-6.88)	7.62 (7.15-8.11)	8.88 (8.32-9.45)	9.84 (9.21-10.5)	11.1 (10.4-11.8)	12.1 (11.2-12.8)	13.0 (12.1-13.8)	13.9 (12.9-14.8)	15.0 (13.9-16.1)	15.9 (14.6-17.0)
45-day	8.27 (7.79-8.77)	9.70 (9.14-10.3)	11.1 (10.5-11.8)	12.2 (11.5-13.0)	13.6 (12.8-14.5)	14.6 (13.7-15.5)	15.6 (14.6-16.6)	16.5 (15.4-17.6)	17.7 (16.5-18.8)	18.5 (17.2-19.7)
60-day	9.99 (9.45-10.6)	11.7 (11.1-12.4)	13.3 (12.6-14.1)	14.5 (13.8-15.4)	16.1 (15.2-17.0)	17.2 (16.2-18.1)	18.2 (17.1-19.2)	19.1 (18.0-20.2)	20.3 (19.0-21.5)	21.0 (19.7-22.3)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
 Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
 Please refer to NOAA Atlas 14 document for more information.

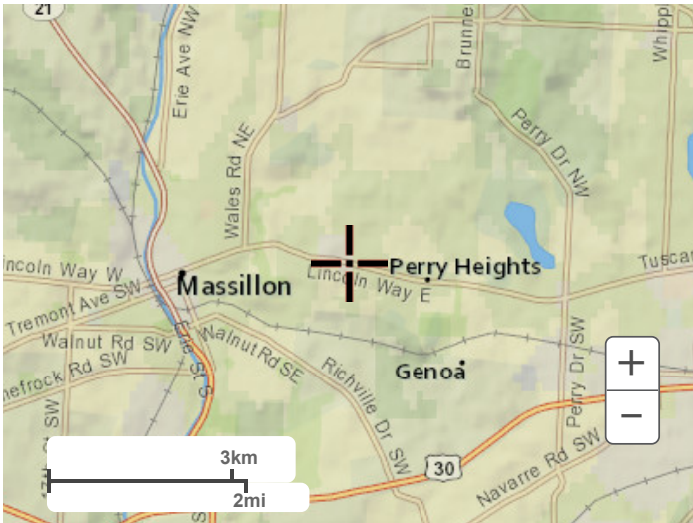
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PF graphical



Maps & aerials

Small scale terrain



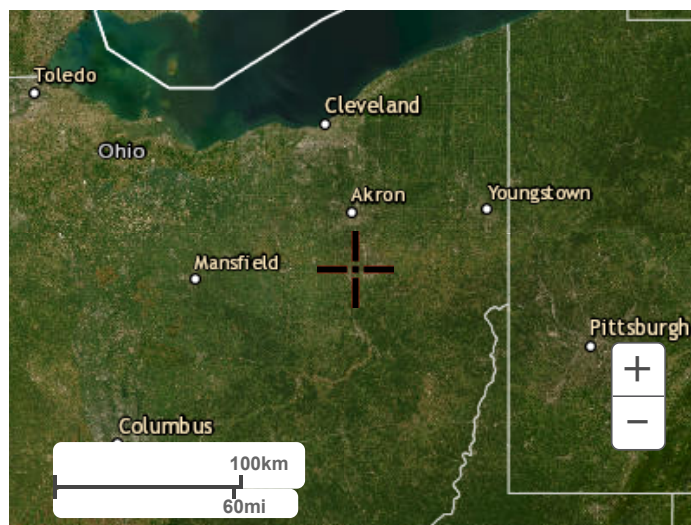
Large scale terrain



Large scale map



Large scale aerial



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1325 East West Highway
Silver Spring, MD 20910
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NOAA Atlas 14, Volume 2, Version 3
Location name: Massillon, Ohio, USA*
Latitude: 40.7975°, Longitude: -81.4889°
Elevation: 1129.43 ft**
 * source: ESRI Maps
 ** source: USGS



POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

NOAA, National Weather Service, Silver Spring, Maryland

[PF tabular](#) | [PF graphical](#) | [Maps & aerals](#)

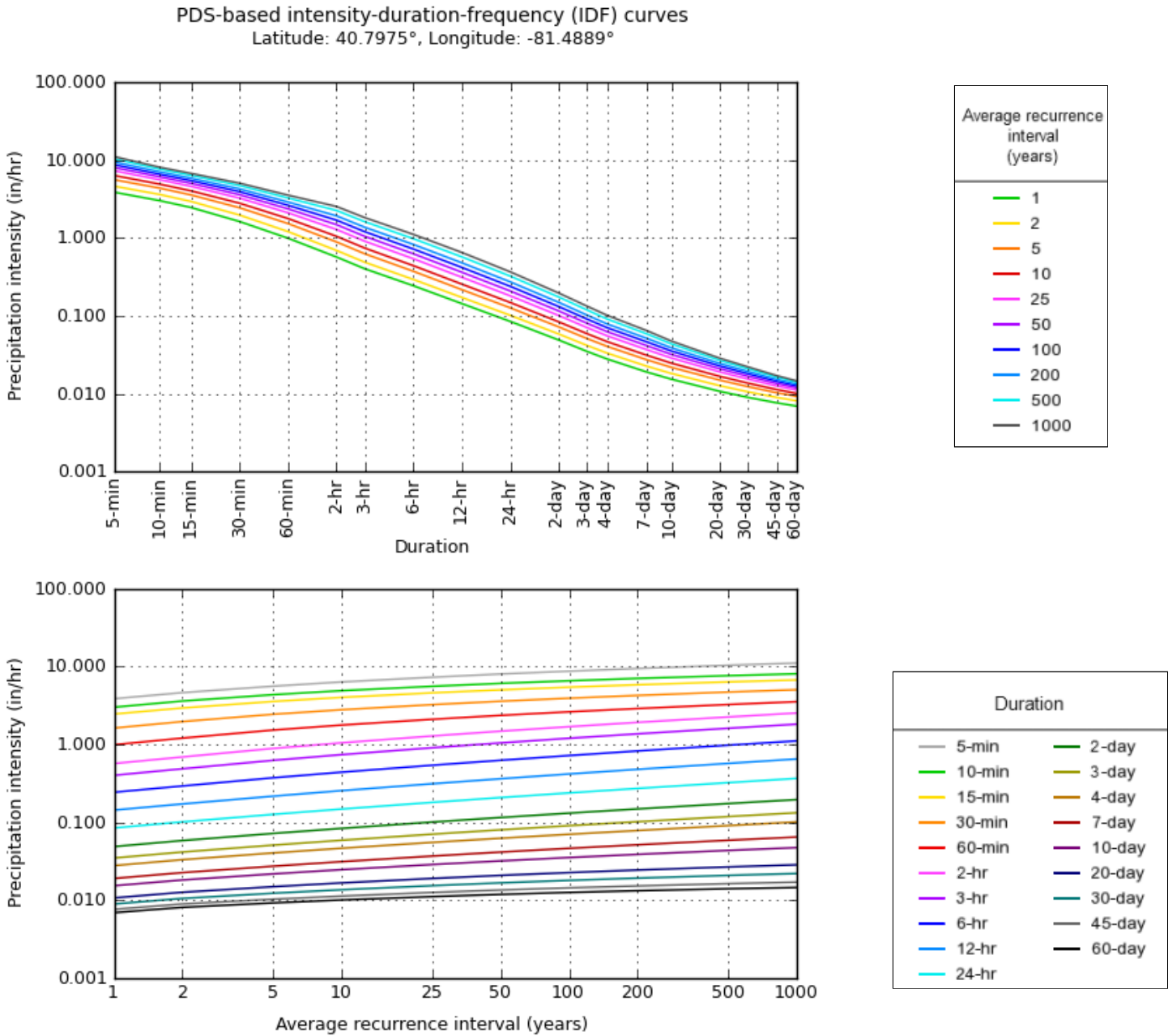
PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	3.86 (3.53-4.25)	4.62 (4.21-5.05)	5.59 (5.09-6.13)	6.34 (5.76-6.94)	7.28 (6.60-7.97)	8.02 (7.22-8.75)	8.71 (7.82-9.50)	9.43 (8.44-10.3)	10.4 (9.24-11.3)	11.1 (9.80-12.0)
10-min	3.01 (2.75-3.30)	3.61 (3.29-3.95)	4.35 (3.95-4.76)	4.90 (4.45-5.35)	5.57 (5.05-6.10)	6.08 (5.47-6.64)	6.56 (5.89-7.15)	7.04 (6.29-7.67)	7.63 (6.79-8.30)	8.06 (7.13-8.77)
15-min	2.46 (2.24-2.70)	2.94 (2.68-3.22)	3.56 (3.24-3.90)	4.02 (3.64-4.39)	4.59 (4.15-5.02)	5.02 (4.52-5.47)	5.43 (4.88-5.92)	5.83 (5.22-6.36)	6.35 (5.65-6.91)	6.72 (5.94-7.31)
30-min	1.62 (1.48-1.78)	1.97 (1.79-2.15)	2.44 (2.22-2.67)	2.79 (2.53-3.05)	3.24 (2.93-3.54)	3.58 (3.23-3.91)	3.92 (3.52-4.28)	4.26 (3.81-4.64)	4.70 (4.18-5.12)	5.04 (4.46-5.48)
60-min	0.992 (0.906-1.09)	1.21 (1.10-1.32)	1.53 (1.39-1.68)	1.77 (1.61-1.94)	2.10 (1.90-2.30)	2.36 (2.13-2.58)	2.62 (2.35-2.86)	2.89 (2.58-3.15)	3.25 (2.89-3.54)	3.54 (3.13-3.85)
2-hr	0.569 (0.516-0.626)	0.690 (0.626-0.762)	0.888 (0.806-0.978)	1.05 (0.949-1.15)	1.28 (1.16-1.41)	1.48 (1.33-1.62)	1.69 (1.51-1.84)	1.92 (1.71-2.09)	2.25 (1.99-2.45)	2.53 (2.23-2.75)
3-hr	0.402 (0.364-0.445)	0.487 (0.441-0.539)	0.625 (0.565-0.690)	0.740 (0.667-0.816)	0.906 (0.814-0.997)	1.05 (0.936-1.15)	1.20 (1.07-1.31)	1.37 (1.21-1.49)	1.61 (1.42-1.76)	1.82 (1.59-1.98)
6-hr	0.243 (0.220-0.272)	0.293 (0.266-0.328)	0.373 (0.337-0.416)	0.441 (0.397-0.490)	0.541 (0.485-0.600)	0.626 (0.559-0.693)	0.720 (0.639-0.793)	0.825 (0.727-0.906)	0.978 (0.853-1.07)	1.11 (0.960-1.21)
12-hr	0.144 (0.130-0.161)	0.172 (0.156-0.193)	0.217 (0.196-0.242)	0.255 (0.231-0.284)	0.313 (0.281-0.347)	0.363 (0.324-0.402)	0.418 (0.371-0.461)	0.479 (0.423-0.527)	0.571 (0.499-0.627)	0.651 (0.563-0.712)
24-hr	0.085 (0.078-0.093)	0.102 (0.093-0.112)	0.127 (0.116-0.140)	0.148 (0.135-0.163)	0.180 (0.163-0.198)	0.208 (0.187-0.228)	0.239 (0.213-0.261)	0.273 (0.241-0.298)	0.323 (0.281-0.353)	0.367 (0.314-0.401)
2-day	0.049 (0.045-0.054)	0.058 (0.054-0.064)	0.072 (0.066-0.079)	0.084 (0.076-0.092)	0.101 (0.092-0.111)	0.115 (0.104-0.126)	0.131 (0.118-0.144)	0.149 (0.132-0.163)	0.174 (0.152-0.191)	0.196 (0.169-0.215)
3-day	0.035 (0.032-0.038)	0.042 (0.038-0.046)	0.051 (0.047-0.056)	0.059 (0.054-0.064)	0.071 (0.064-0.077)	0.080 (0.073-0.087)	0.091 (0.082-0.099)	0.102 (0.091-0.111)	0.119 (0.105-0.130)	0.133 (0.116-0.145)
4-day	0.028 (0.026-0.030)	0.033 (0.031-0.036)	0.041 (0.037-0.044)	0.047 (0.043-0.051)	0.055 (0.051-0.060)	0.063 (0.057-0.068)	0.070 (0.064-0.076)	0.079 (0.071-0.085)	0.091 (0.081-0.099)	0.101 (0.089-0.111)
7-day	0.019 (0.018-0.021)	0.023 (0.021-0.025)	0.027 (0.025-0.030)	0.031 (0.029-0.034)	0.037 (0.034-0.040)	0.042 (0.038-0.045)	0.046 (0.042-0.050)	0.052 (0.047-0.056)	0.059 (0.053-0.064)	0.065 (0.058-0.070)
10-day	0.015 (0.014-0.017)	0.018 (0.017-0.020)	0.022 (0.020-0.023)	0.025 (0.023-0.027)	0.029 (0.027-0.031)	0.032 (0.029-0.034)	0.035 (0.032-0.038)	0.039 (0.035-0.042)	0.044 (0.039-0.047)	0.047 (0.043-0.051)
20-day	0.011 (0.010-0.011)	0.013 (0.012-0.014)	0.015 (0.014-0.016)	0.017 (0.016-0.018)	0.019 (0.018-0.020)	0.021 (0.019-0.022)	0.023 (0.021-0.024)	0.024 (0.023-0.026)	0.027 (0.025-0.029)	0.029 (0.026-0.031)
30-day	0.009 (0.008-0.010)	0.011 (0.010-0.011)	0.012 (0.012-0.013)	0.014 (0.013-0.015)	0.015 (0.014-0.016)	0.017 (0.016-0.018)	0.018 (0.017-0.019)	0.019 (0.018-0.021)	0.021 (0.019-0.022)	0.022 (0.020-0.024)
45-day	0.008 (0.007-0.008)	0.009 (0.008-0.010)	0.010 (0.010-0.011)	0.011 (0.011-0.012)	0.013 (0.012-0.013)	0.014 (0.013-0.014)	0.014 (0.014-0.015)	0.015 (0.014-0.016)	0.016 (0.015-0.017)	0.017 (0.016-0.018)
60-day	0.007 (0.007-0.007)	0.008 (0.008-0.009)	0.009 (0.009-0.010)	0.010 (0.010-0.011)	0.011 (0.011-0.012)	0.012 (0.011-0.013)	0.013 (0.012-0.013)	0.013 (0.012-0.014)	0.014 (0.013-0.015)	0.015 (0.014-0.016)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
 Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
 Please refer to NOAA Atlas 14 document for more information.

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PF graphical



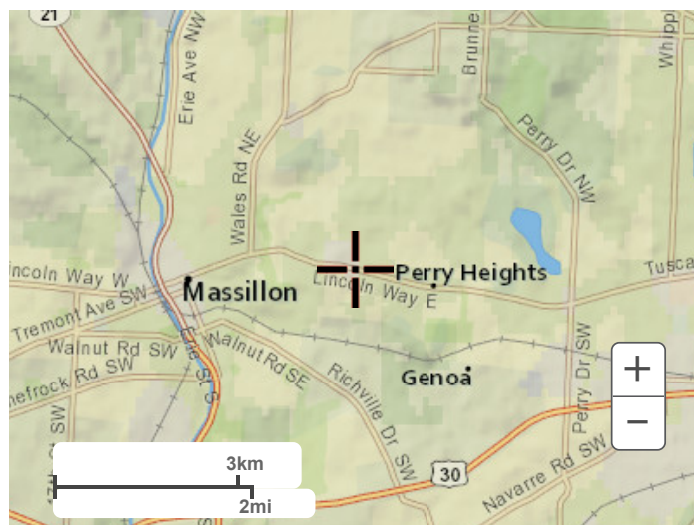
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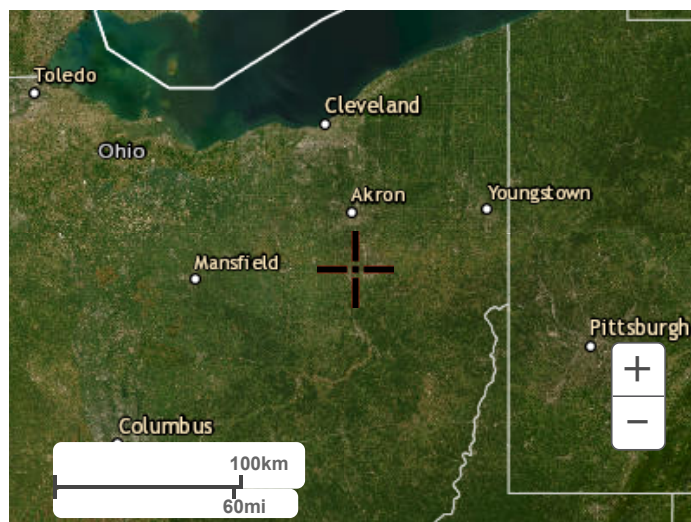
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Appendix H: Post Construction Operation and Maintenance Plan

The owner of the property affected shall inspect and maintain the following stormwater management systems frequently, especially after heavy rainfalls, but at least on an annual basis unless otherwise specified.

STORMWATER FACILITY	TYPE OF ACTION
1. Lawn and Landscaped Areas	All lawn areas shall be kept clear of any materials that block the flow of stormwater. Rills and small gullies shall immediately be filled and seeded or have sod placed in them. The lawn shall be kept mowed, tree seedlings shall be removed, and litter shall be removed from landscaped areas.
2. Swales	All grassed swales showing signs of erosion, scour, or channelization shall be repaired, reinforced, and revegetated immediately. All swales shall be repaired to the original plan requirements. Mowing shall take place no less than twice per year at a height of no less than three inches. Grasses shall not be allowed to grow to a height that permits branching or bending. Mowing shall only take place when the ground is dry and able to support machinery.
3. Catch Basin/Curb Inlet Grates	The grate openings to these structures must be kept clear of any clogging or the blocking of stormwater flow.
4. Catch Basin/Curb Inlet Sumps	Sumps shall visually be inspected every 3 months. Siltation shall be removed and disposed of offsite when the sump depth is within 3" of the outlet pipe invert elevation. The removal of siltation should occur a minimum of once per year.
5. Underground Stormwater System	Standpipes, outlet structures, inlet and outlet pipes, and chambers shall be kept clear of debris at all times. Non-structurally sound devices shall be replaced. Special attention shall be given to the system outlet structure to ensure that orifice openings are clear of debris. These appurtenances shall be inspected semi-annually, in the spring and fall seasons. Follow underground detention system manufacturer's specifications for maintenance procedures. Contractor to remove all sediment and debris from the system prior to completing the storm system installation. Sediment shall be regularly removed from the system in accordance with manufacturers recommendations. Cleaning, removal, and deposit of silt from the underground stormwater quality system shall be done by means and methods acceptable to the local jurisdiction.
6. Contech Cascade Hydrodynamic Separator	Inspection of the structure shall be completed annually at a minimum by qualified maintenance personnel. Sediment in the bottom of the structure shall be inspected to verify sediment is less than 16" deep. If sediment is greater than 16" deep, the sediment shall be removed per Contech guidelines and the structure shall be inspected by qualified personnel.
7. Record of Maintenance	The operation and maintenance plan shall remain onsite and be available for inspection when requested by the local governing agency. When requested, the owner shall make available for inspection all maintenance records to the department or agent for the life of the system.