GRADY CONSULTING, L.L.C.
Registered Professional Civil Engineers & Land Surveyors

STORMWATER MANAGEMENT DESIGN CALCULATIONS

715 Washington Street
Assessors Map F9 Lots 24 & 40

Pembroke, Massachusetts

Prepared for

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December 18, 2020

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Summary

This analysis was prepared to demonstrate Compliance with the Massachusetts Stormwater Management Regulations and the Town of Pembroke Planning Board Rules and Regulations for Stormwater Management. The proposed project is for the construction of one 5000 square foot structure for light industrial use.

The existing site is a vacant parcel located within the Town of Pembroke Residential-Commercial Zoning District. The proposed stormwater system consists of catch basins, sediment forebays, two infiltration basins and one subsurface infiltration system for the roof proposed building.

Pre-Development Stormwater flows are separated into catchments areas and routed as follows:

Pre 3 – Existing woodland that flows to an existing bordering vegetated wetland on the north western portion of the property.

Post-Development Stormwater flows are separated into 3 catchment areas. A proposed stormwater system consisting of one sediment forebay and an infiltration basin has been designed at an infiltration rate of 2.41 in/hr.

Post 5 – Roof drains flow to the subsurface infiltration basin.
Post 6 – Flows to infiltration basin #1.
Post 7 – Flows to Infiltration Basin#2
Post 8 – Flows to an existing bordering vegetated wetland on the northern portion of the property

The design, as proposed, reduces peak runoff rates, improves and promotes infiltration, and improves stormwater quality and treatment prior to discharge.

This analysis is divided into the following sections:

Section I Overall Site Analysis
Section II Compliance with Massachusetts Storm water Management Regulations
Section III Operation And Maintenance Plan

The calculations have been performed for the 2, 10, 25, and 100-year 24 hour storm event, using the HydroCAD 10.00 computer program. This computer program is based upon the Soils Conservation Service (SCS) TR-20 and TR-55 computer models and uses the SCS Curvilinear Unit rainfall distribution.

Peak Flow Summary

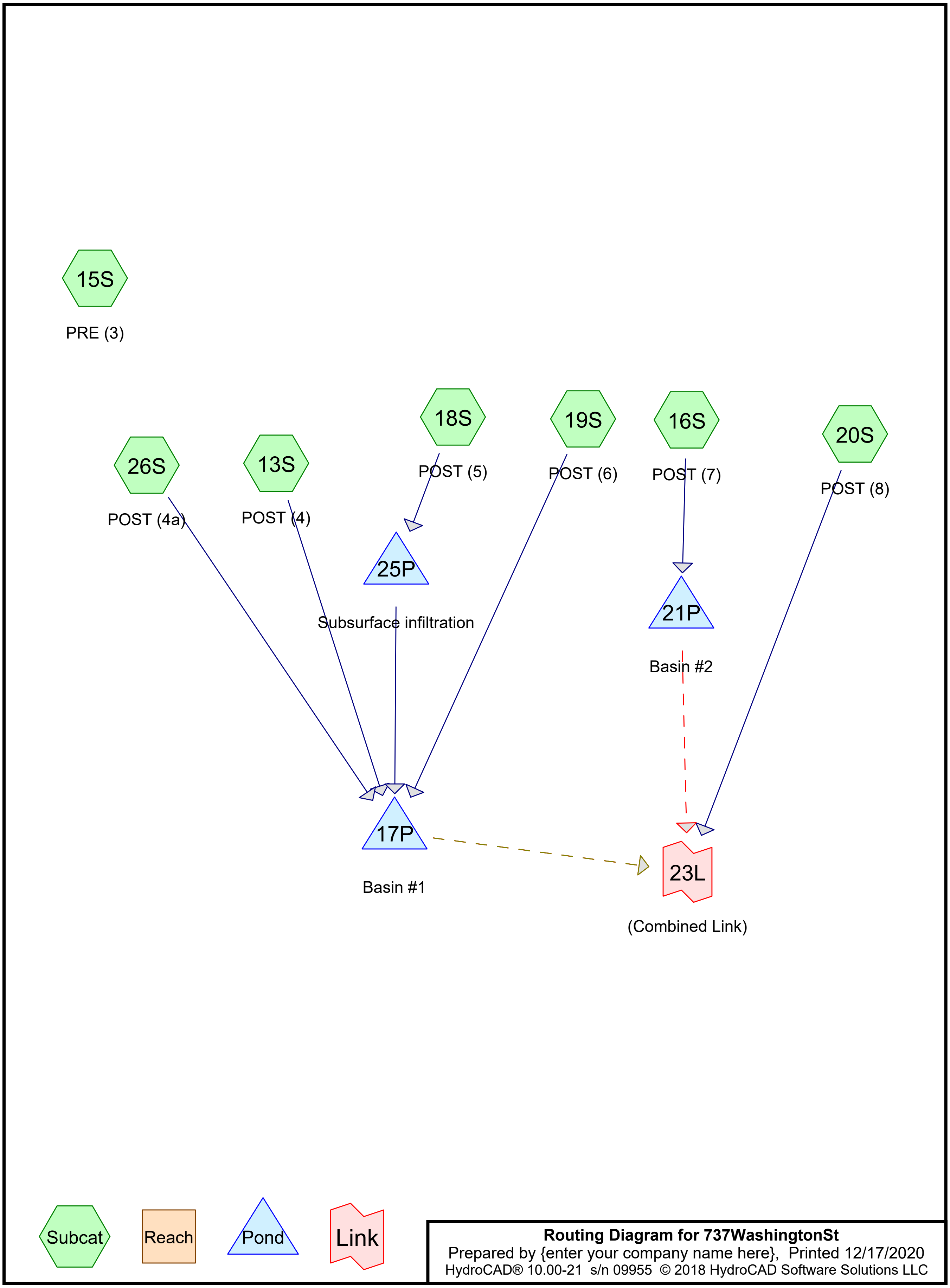
	2Year	10 Year	25 Year	100 Year
Pre 1	1.96	4.02	5.60	8.20
Total	1.96	4.02	5.60	8.20

Post 5	0	0	0.00	0.20
Basin #1 Out	0.00	0.31	0.96	1.37
tertiary	1.09	2.02	2.36	2.88
Post 7 Routed	0.32	0.56	0.70	0.92
Post 8	0.66	1.35	1.87	2.75
	2.07	4.24	5.89	8.12
Pre 1 vs	1.96	4.02	5.60	8.20
Combined Link	1.71	3.68	5.52	7.42

Elevations	2Year	10 Year	25 Year	100 Year	Top	bottom
Basin #1	79.59	80.13	10.33	80.66	81.66	77.00
Basin #2	74.68	74.72	74.74	74.77	75.77	74.00
Subsurface system	81.47	82.6	83.44	84.39	84.5	79.00

Forbay Sizing	(Impervious SF)	(1/12)	0.1 inch/ imp acre	Required Volume		Provided Volume
Forebay Basin #1	27582	0.083333	0.1	230	CF	299 cf provided at el=81.0
Forebay Basin #2	4427	0.083333	0.1	37	CF	52 cf provided at el=74.5

Section I
Overall Site Analysis



Routing Diagram for 737WashingtonSt
Prepared by {enter your company name here}, Printed 12/17/2020
HydroCAD® 10.00-21 s/n 09955 © 2018 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.109	79	50-75% Grass cover, Fair, HSG C (13S)
0.452	74	>75% Grass cover, Good, HSG C (16S, 19S, 20S)
0.905	98	Paved parking, HSG C (13S, 16S, 26S)
0.115	98	Roofs, HSG C (18S)
2.994	70	Woods, Good, HSG C (13S, 15S, 20S)
4.575	**77**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
4.575	HSG C	13S, 15S, 16S, 18S, 19S, 20S, 26S
0.000	HSG D	
0.000	Other	
4.575		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.109	0.000	0.000	0.109	50-75% Grass cover, Fair	13S
0.000	0.000	0.452	0.000	0.000	0.452	>75% Grass cover, Good	16S, 19S, 20S
0.000	0.000	0.905	0.000	0.000	0.905	Paved parking	13S, 16S, 26S
0.000	0.000	0.115	0.000	0.000	0.115	Roofs	18S
0.000	0.000	2.994	0.000	0.000	2.994	Woods, Good	13S, 15S, 20S
0.000	**0.000**	**4.575**	**0.000**	**0.000**	**4.575**	**TOTAL AREA**	

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: POST (4) Runoff Area=33,810 sf 81.58% Impervious Runoff Depth=2.74"
Flow Length=298' Tc=10.0 min CN=94 Runoff=2.06 cfs 0.177 af

Subcatchment 15S: PRE (3) Runoff Area=97,629 sf 0.00% Impervious Runoff Depth=0.95"
Flow Length=382' Tc=10.0 min CN=70 Runoff=1.96 cfs 0.177 af

Subcatchment 16S: POST (7) Runoff Area=7,754 sf 57.09% Impervious Runoff Depth=2.18"
Flow Length=156' Slope=0.0500 '/' Tc=10.0 min CN=88 Runoff=0.39 cfs 0.032 af

Subcatchment 18S: POST (5) Runoff Area=5,000 sf 100.00% Impervious Runoff Depth=3.17"
Tc=10.0 min CN=98 Runoff=0.33 cfs 0.030 af

Subcatchment 19S: POST (6) Runoff Area=14,954 sf 0.00% Impervious Runoff Depth=1.17"
Flow Length=188' Tc=10.0 min CN=74 Runoff=0.39 cfs 0.034 af

Subcatchment 20S: POST (8) Runoff Area=32,707 sf 0.00% Impervious Runoff Depth=0.95"
Flow Length=134' Tc=10.0 min CN=70 Runoff=0.66 cfs 0.059 af

Subcatchment 26S: POST (4a) Runoff Area=7,416 sf 100.00% Impervious Runoff Depth=3.17"
Tc=10.0 min CN=98 Runoff=0.49 cfs 0.045 af

Pond 17P: Basin #1 Peak Elev=79.59' Storage=4,011 cf Inflow=2.93 cfs 0.256 af
Discarded=0.13 cfs 0.153 af Secondary=0.00 cfs 0.000 af Tertiary=1.09 cfs 0.103 af Outflow=1.22 cfs 0.256 af

Pond 21P: Basin #2 Peak Elev=74.68' Storage=366 cf Inflow=0.39 cfs 0.032 af
Discarded=0.02 cfs 0.020 af Secondary=0.32 cfs 0.013 af Outflow=0.34 cfs 0.032 af

Pond 25P: Subsurface infiltration Peak Elev=81.47' Storage=0.012 af Inflow=0.33 cfs 0.030 af
Discarded=0.03 cfs 0.030 af Primary=0.00 cfs 0.000 af Outflow=0.03 cfs 0.030 af

Link 23L: (Combined Link) Inflow=1.71 cfs 0.175 af
Primary=1.71 cfs 0.175 af

Total Runoff Area = 4.575 ac Runoff Volume = 0.554 af Average Runoff Depth = 1.45"
77.71% Pervious = 3.555 ac 22.29% Impervious = 1.020 ac

Summary for Subcatchment 13S: POST (4)

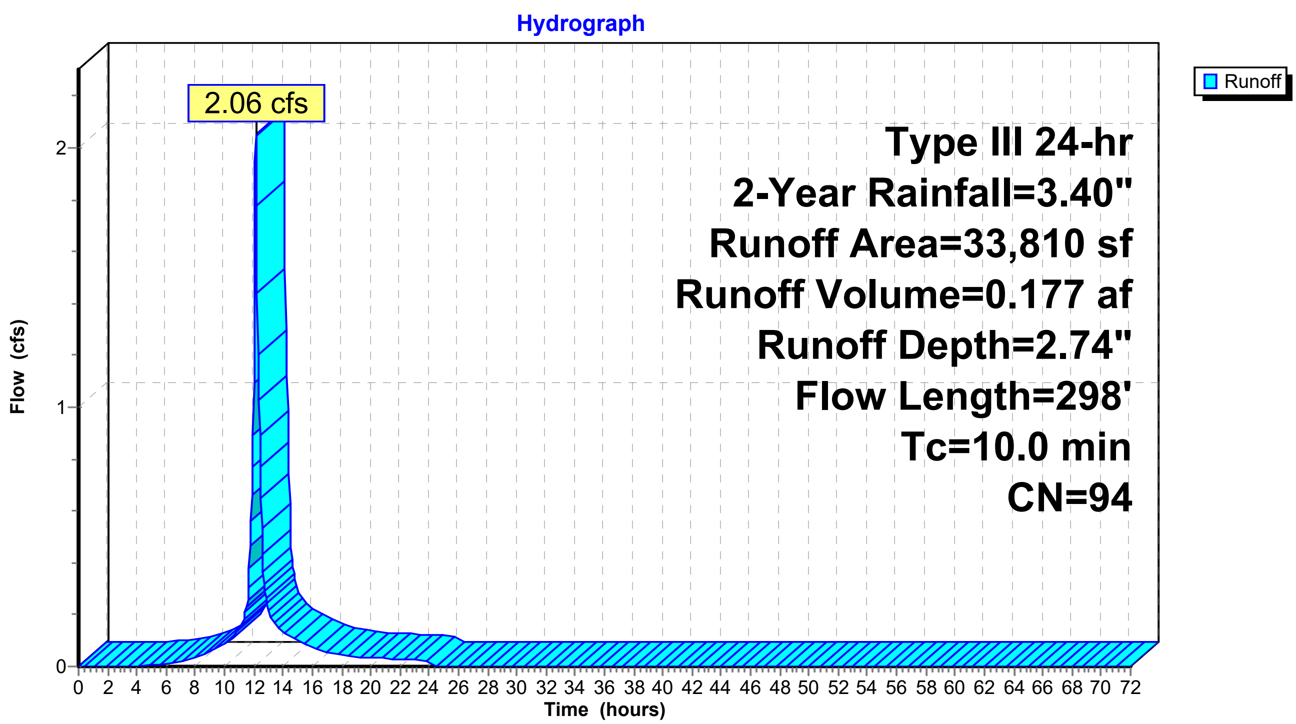
Runoff = 2.06 cfs @ 12.14 hrs, Volume= 0.177 af, Depth= 2.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
27,582	98	Paved parking, HSG C
1,469	70	Woods, Good, HSG C
4,759	79	50-75% Grass cover, Fair, HSG C
33,810	94	Weighted Average
6,228	77	18.42% Pervious Area
27,582	98	81.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	40	0.0500	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
0.1	10	0.0500	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
1.1	248	0.0370	3.90		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
8.1	298	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 13S: POST (4)



Summary for Subcatchment 15S: PRE (3)

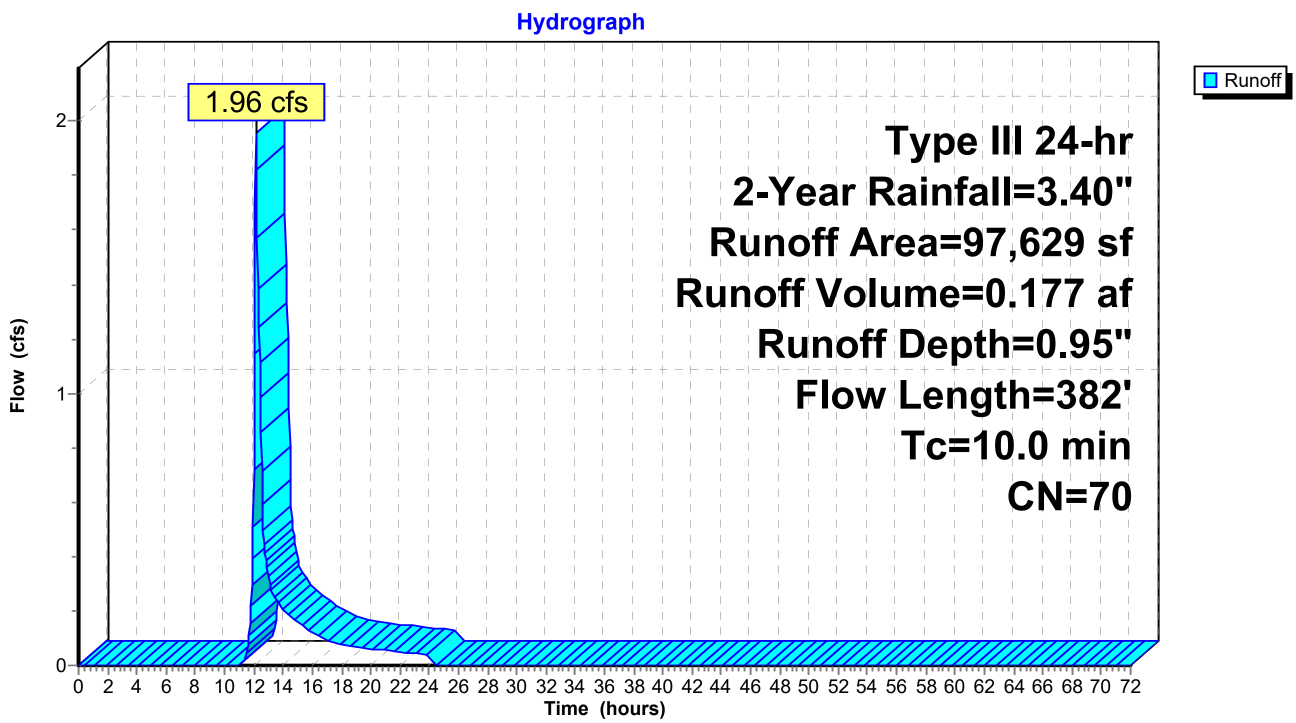
Runoff = 1.96 cfs @ 12.16 hrs, Volume= 0.177 af, Depth= 0.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
97,629	70	Woods, Good, HSG C
97,629	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
2.6	138	0.0320	0.89		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	146	0.0710	1.33		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.5	48	0.0850	1.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.7	382	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 15S: PRE (3)



Summary for Subcatchment 16S: POST (7)

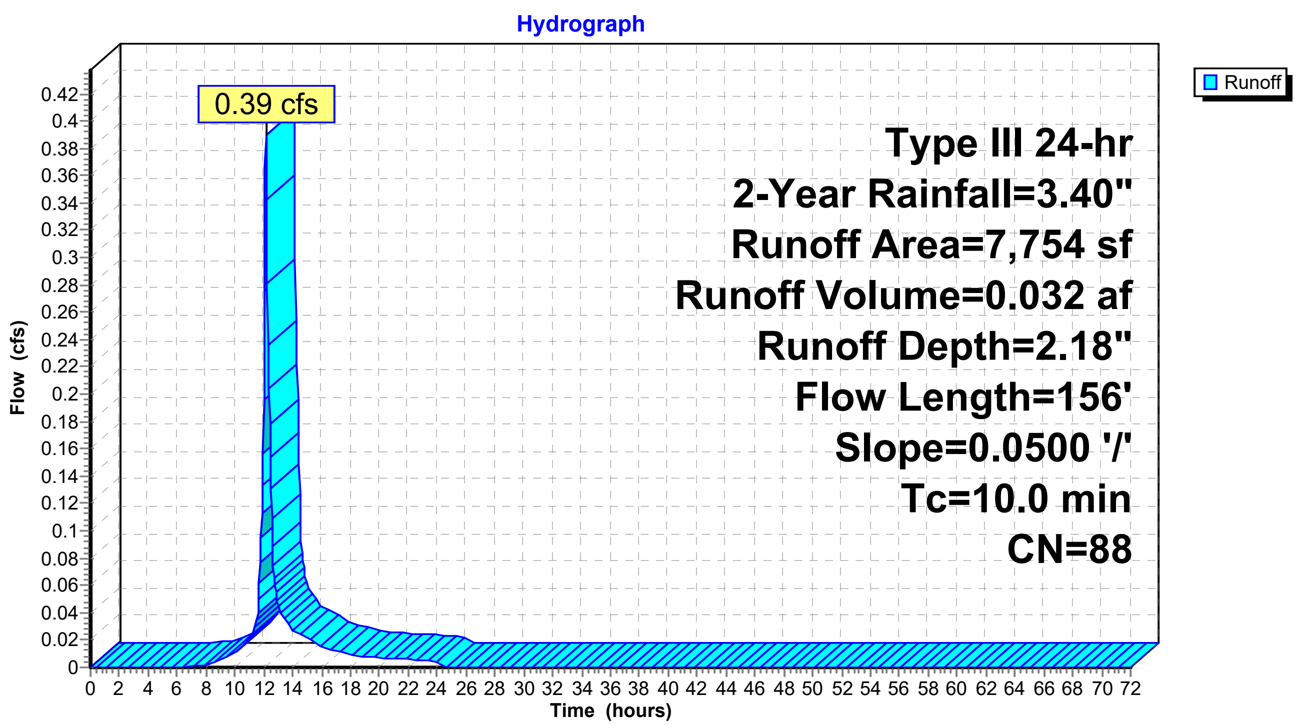
Runoff = 0.39 cfs @ 12.14 hrs, Volume= 0.032 af, Depth= 2.18"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
3,327	74	>75% Grass cover, Good, HSG C
4,427	98	Paved parking, HSG C
7,754	88	Weighted Average
3,327	74	42.91% Pervious Area
4,427	98	57.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	50	0.0500	1.78		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
0.4	106	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.9	156	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 16S: POST (7)



Summary for Subcatchment 18S: POST (5)

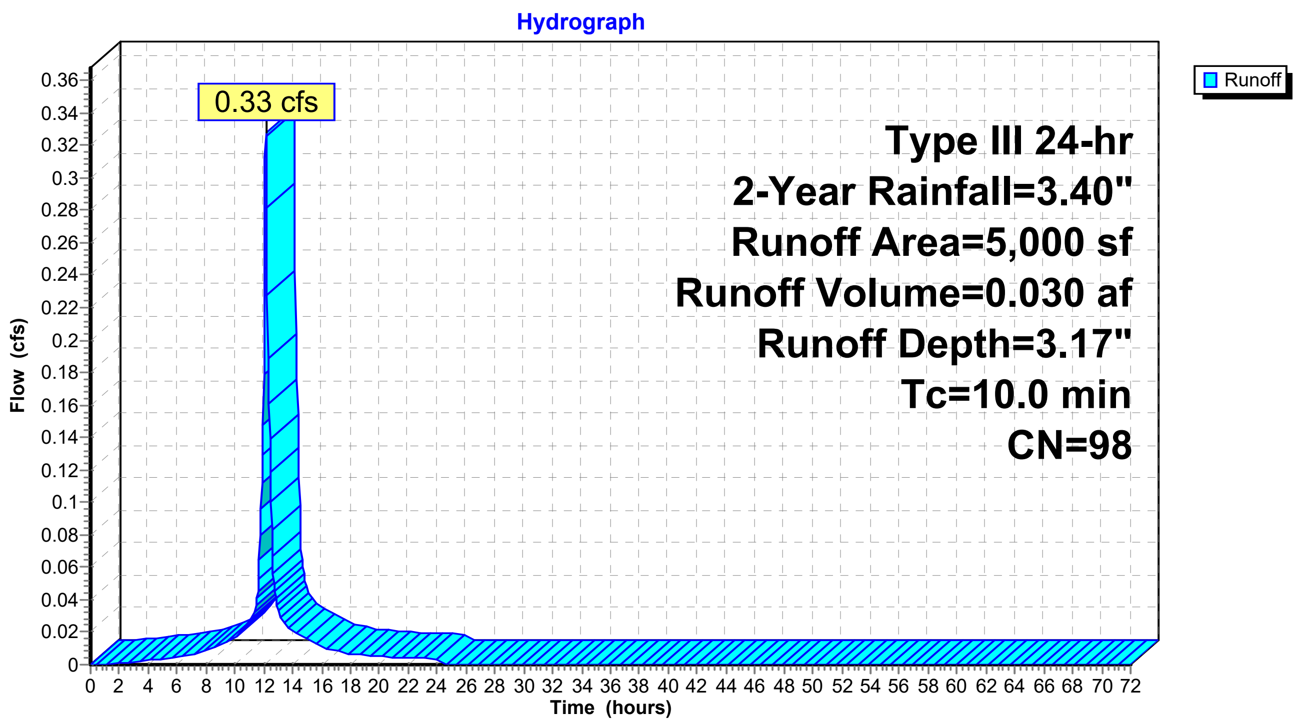
Runoff = 0.33 cfs @ 12.14 hrs, Volume= 0.030 af, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,000	98	Roofs, HSG C
5,000	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Estimate**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 18S: POST (5)



Summary for Subcatchment 19S: POST (6)

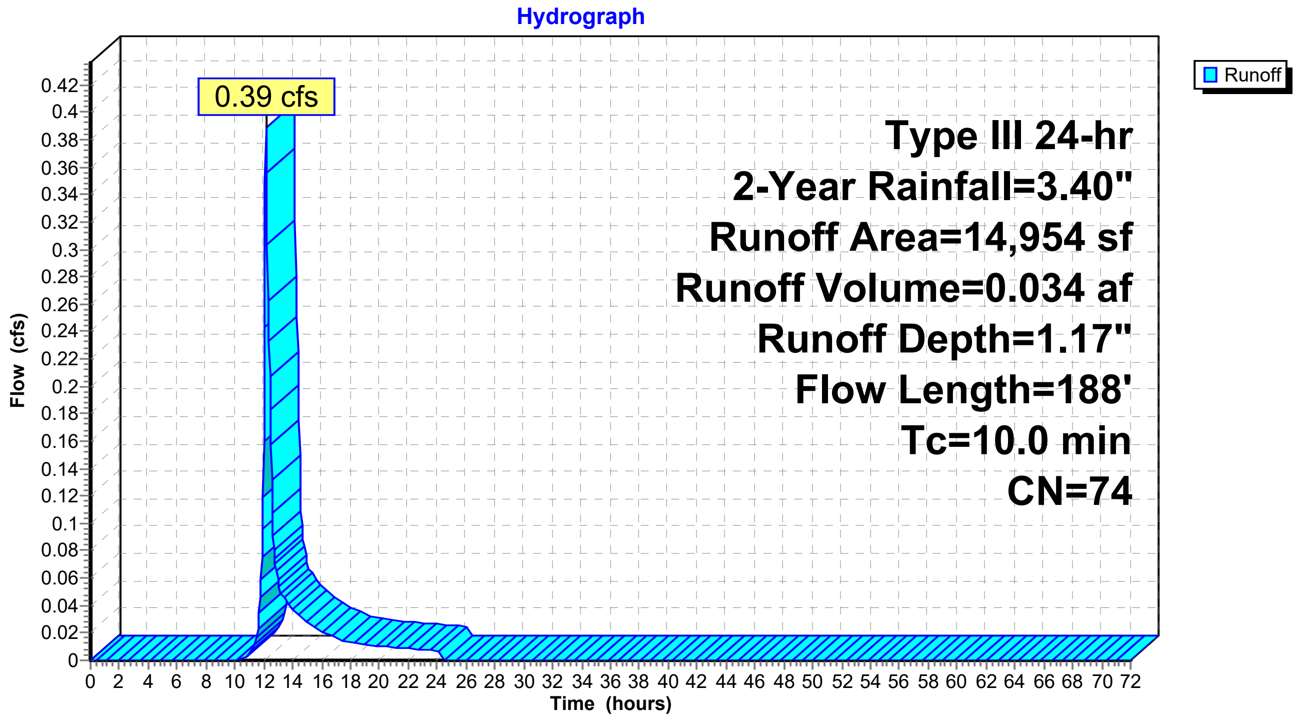
Runoff = 0.39 cfs @ 12.15 hrs, Volume= 0.034 af, Depth= 1.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
14,954	74	>75% Grass cover, Good, HSG C
14,954	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.40"
1.2	102	0.0400	1.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	36	0.3300	4.02		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.3	188	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 19S: POST (6)



Summary for Subcatchment 20S: POST (8)

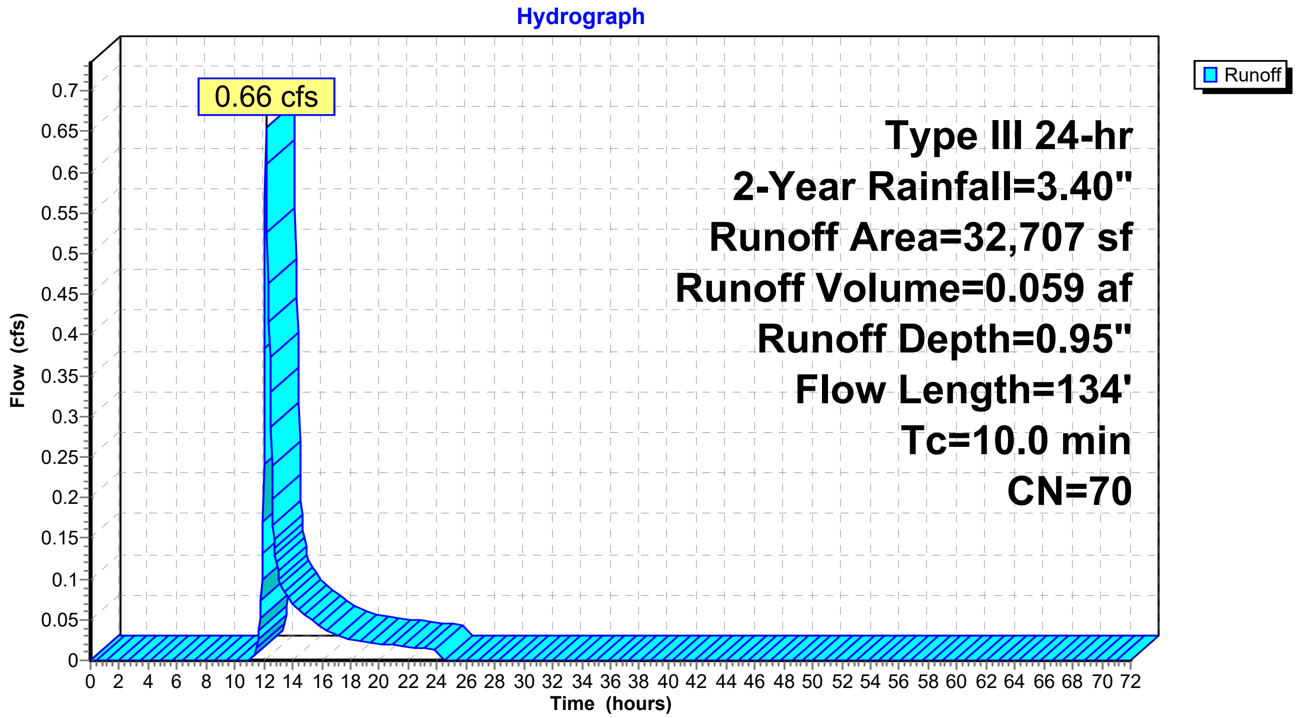
Runoff = 0.66 cfs @ 12.16 hrs, Volume= 0.059 af, Depth= 0.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
1,400	74	>75% Grass cover, Good, HSG C
31,307	70	Woods, Good, HSG C
32,707	70	Weighted Average
32,707	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0800	0.12		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
1.1	84	0.0700	1.32		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.0	134	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 20S: POST (8)



Summary for Subcatchment 26S: POST (4a)

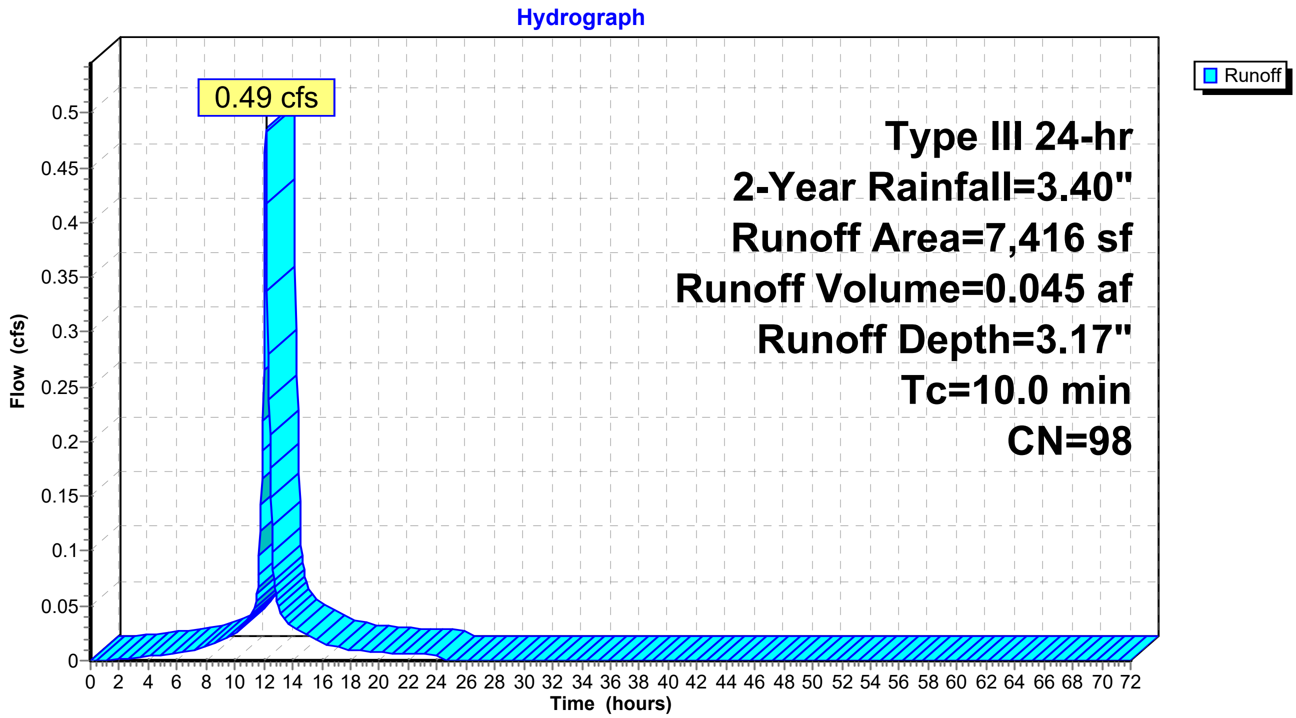
Runoff = 0.49 cfs @ 12.14 hrs, Volume= 0.045 af, Depth= 3.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
7,416	98	Paved parking, HSG C
7,416	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Tc 4A**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 26S: POST (4a)



Summary for Pond 17P: Basin #1

Inflow Area =	1.404 ac,	65.38% Impervious,	Inflow Depth = 2.18"	for 2-Year event
Inflow =	2.93 cfs @	12.14 hrs,	Volume=	0.256 af
Outflow =	1.22 cfs @	12.42 hrs,	Volume=	0.256 af, Atten= 58%, Lag= 17.1 min
Discarded =	0.13 cfs @	12.42 hrs,	Volume=	0.153 af
Secondary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af
Tertiary =	1.09 cfs @	12.42 hrs,	Volume=	0.103 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 79.59' @ 12.42 hrs Surf.Area= 2,285 sf Storage= 4,011 cf

Plug-Flow detention time= 178.5 min calculated for 0.255 af (100% of inflow)
Center-of-Mass det. time= 178.7 min (971.8 - 793.2)

Volume	Invert	Avail.Storage	Storage Description
#1	77.00'	11,397 cf	**Custom Stage Data (Conic)**Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
77.00	934	0	0	934
78.00	1,344	1,133	1,133	1,361
79.00	1,810	1,571	2,704	1,848
80.00	2,609	2,197	4,901	2,664
81.00	3,239	2,918	7,820	3,322
82.00	3,926	3,577	11,397	4,041

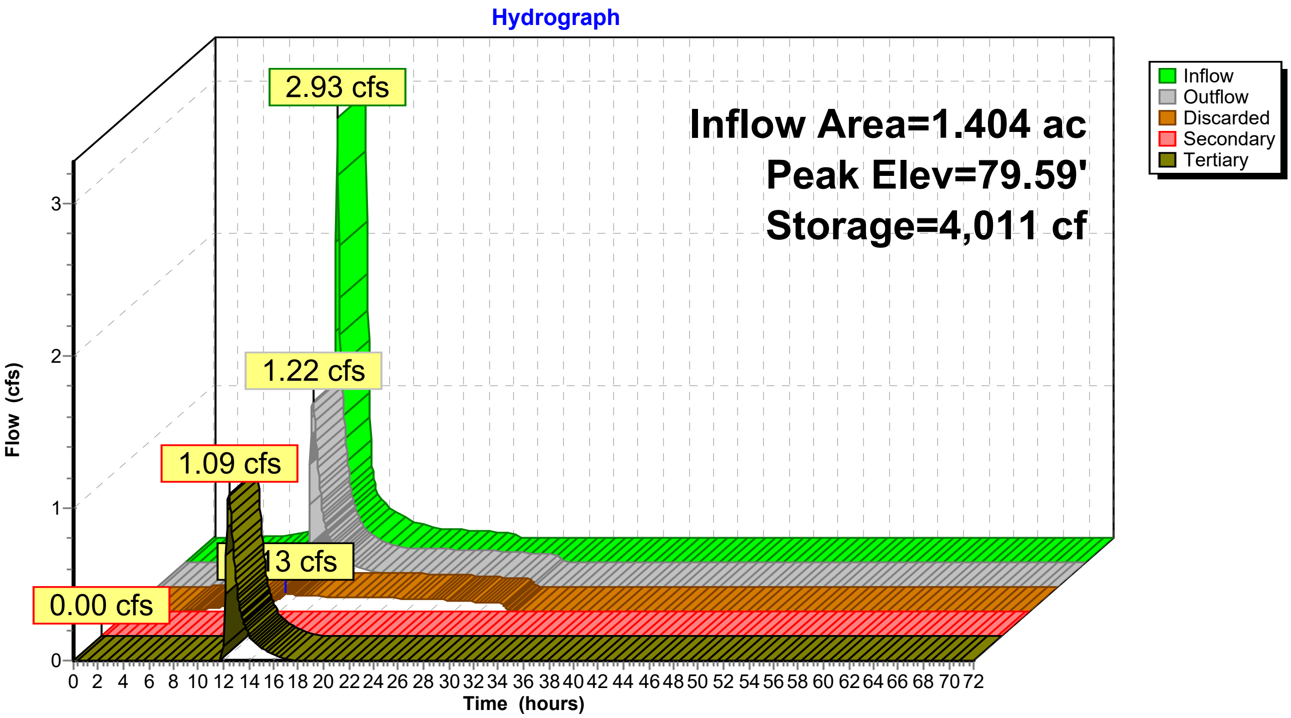
Device	Routing	Invert	Outlet Devices
#1	Discarded	77.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Secondary	80.00'	**8.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	78.75'	**0.5' long Sharp-Crested Rectangular Weir** 1 End Contraction(s) 3.0' Crest Height

Discarded OutFlow Max=0.13 cfs @ 12.42 hrs HW=79.59' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.13 cfs)

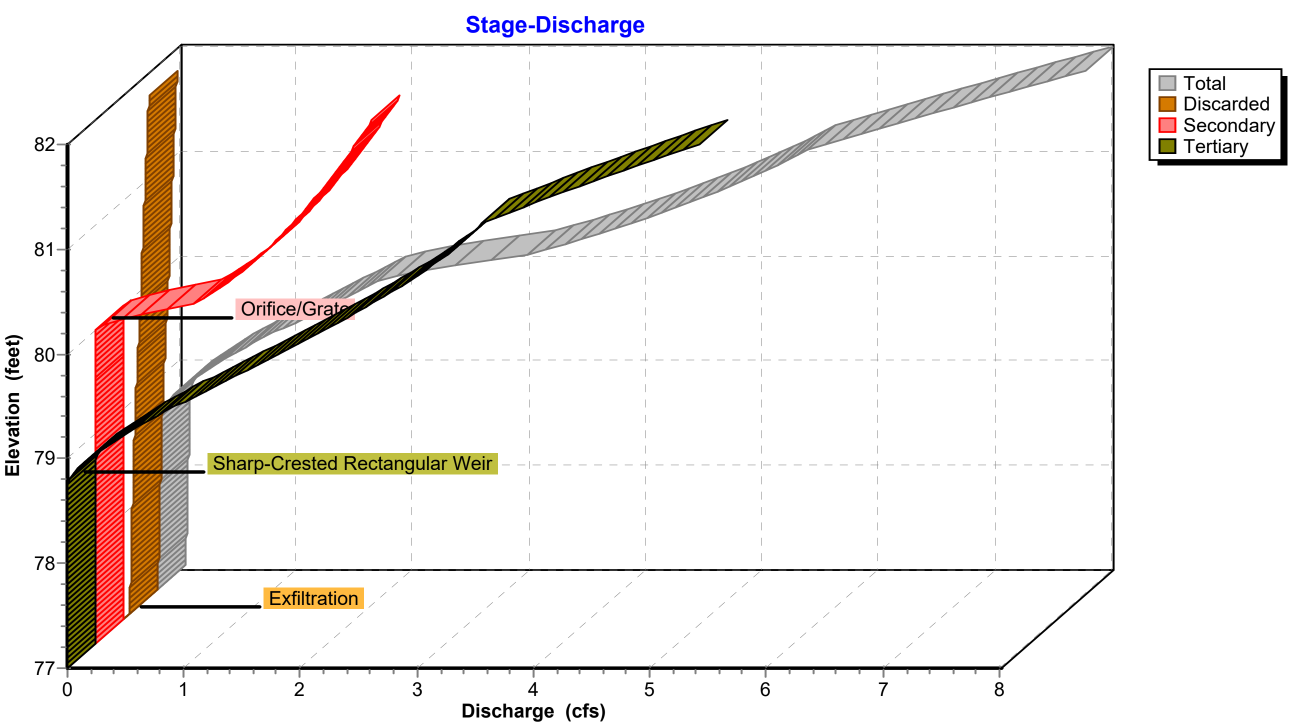
Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=77.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Tertiary OutFlow Max=1.09 cfs @ 12.42 hrs HW=79.59' (Free Discharge)
└─**3=Sharp-Crested Rectangular Weir** (Weir Controls 1.09 cfs @ 3.10 fps)

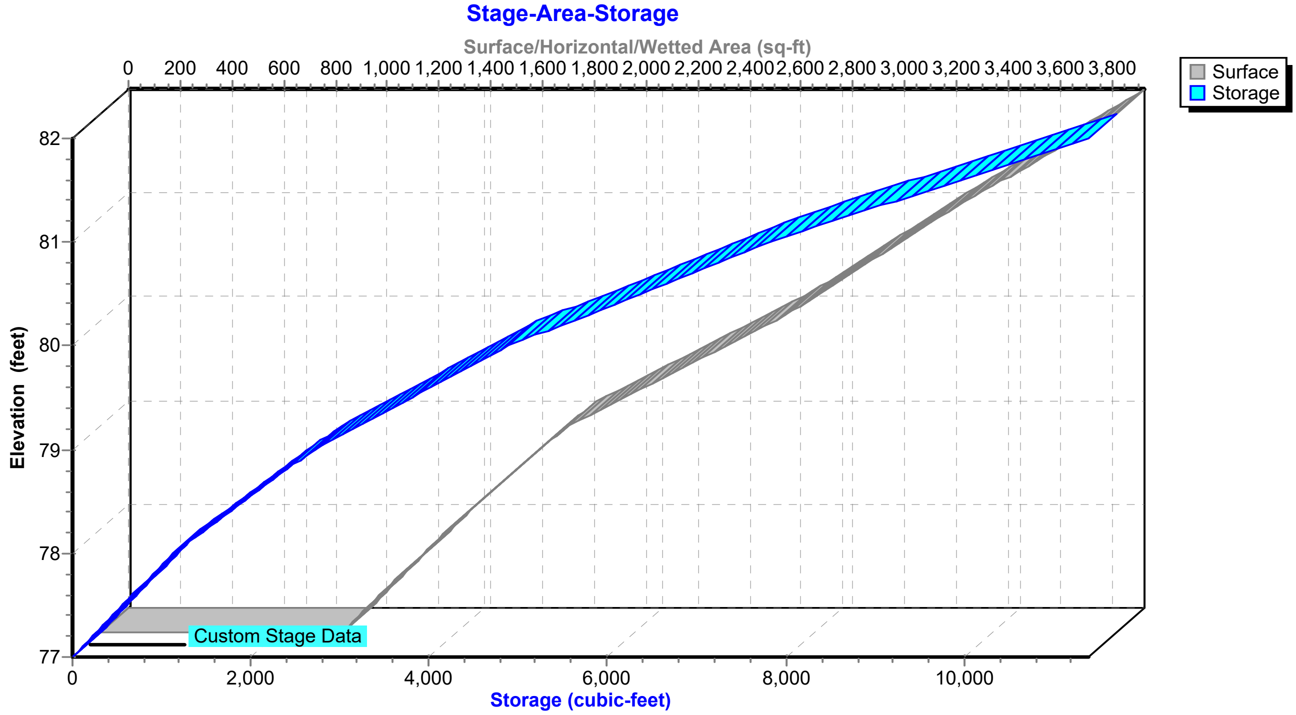
Pond 17P: Basin #1



Pond 17P: Basin #1



Pond 17P: Basin #1



Summary for Pond 21P: Basin #2

Inflow Area = 0.178 ac, 57.09% Impervious, Inflow Depth = 2.18" for 2-Year event
Inflow = 0.39 cfs @ 12.14 hrs, Volume= 0.032 af
Outflow = 0.34 cfs @ 12.22 hrs, Volume= 0.032 af, Atten= 14%, Lag= 4.8 min
Discarded = 0.02 cfs @ 12.22 hrs, Volume= 0.020 af
Secondary = 0.32 cfs @ 12.22 hrs, Volume= 0.013 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 74.68' @ 12.22 hrs Surf.Area= 722 sf Storage= 366 cf

Plug-Flow detention time= 152.6 min calculated for 0.032 af (100% of inflow)
Center-of-Mass det. time= 152.7 min (969.0 - 816.3)

Volume	Invert	Avail.Storage	Storage Description
#1	74.00'	612 cf	**Custom Stage Data (Conic)**Listed below

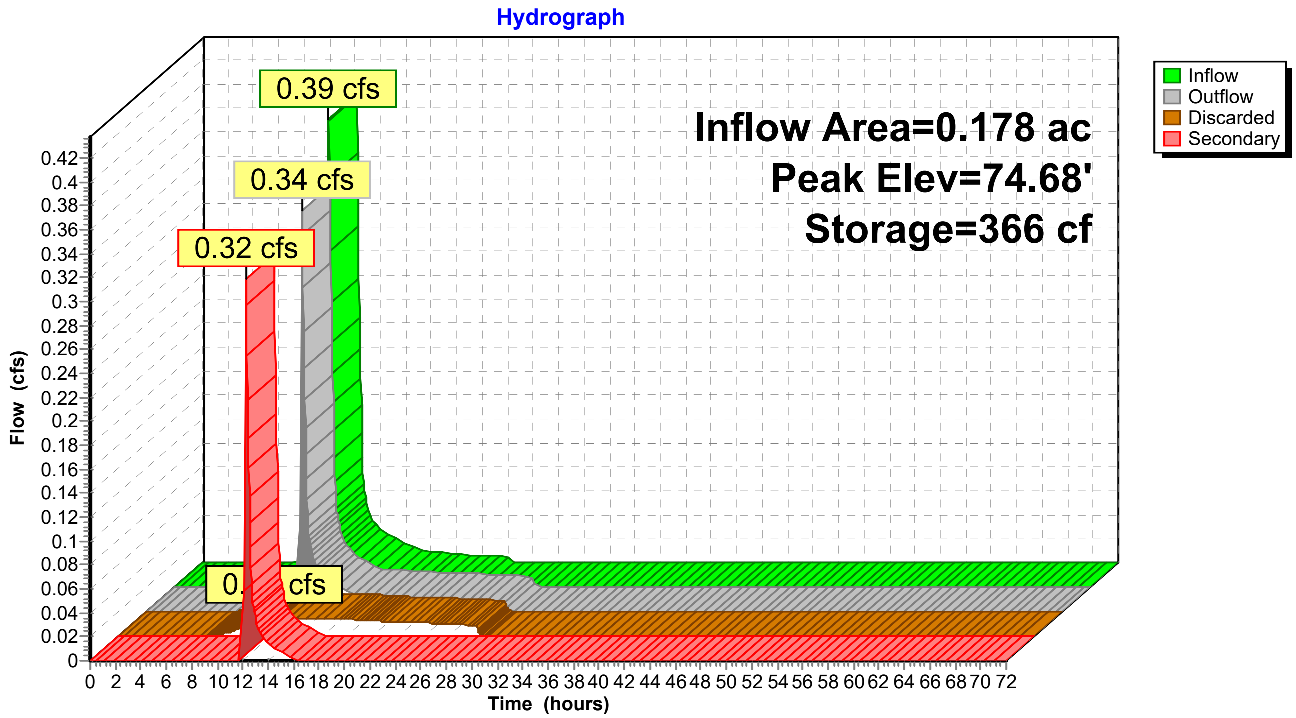
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
74.00	379	0	0	379
74.50	513	222	222	518
75.00	1,081	390	612	1,088

Device	Routing	Invert	Outlet Devices
#1	Discarded	74.00'	**1.020 in/hr Exfiltration over Wetted area**
#2	Secondary	74.60'	**4.0' long x 1.00' rise Sharp-Crested Rectangular Weir** 1 End Contraction(s)

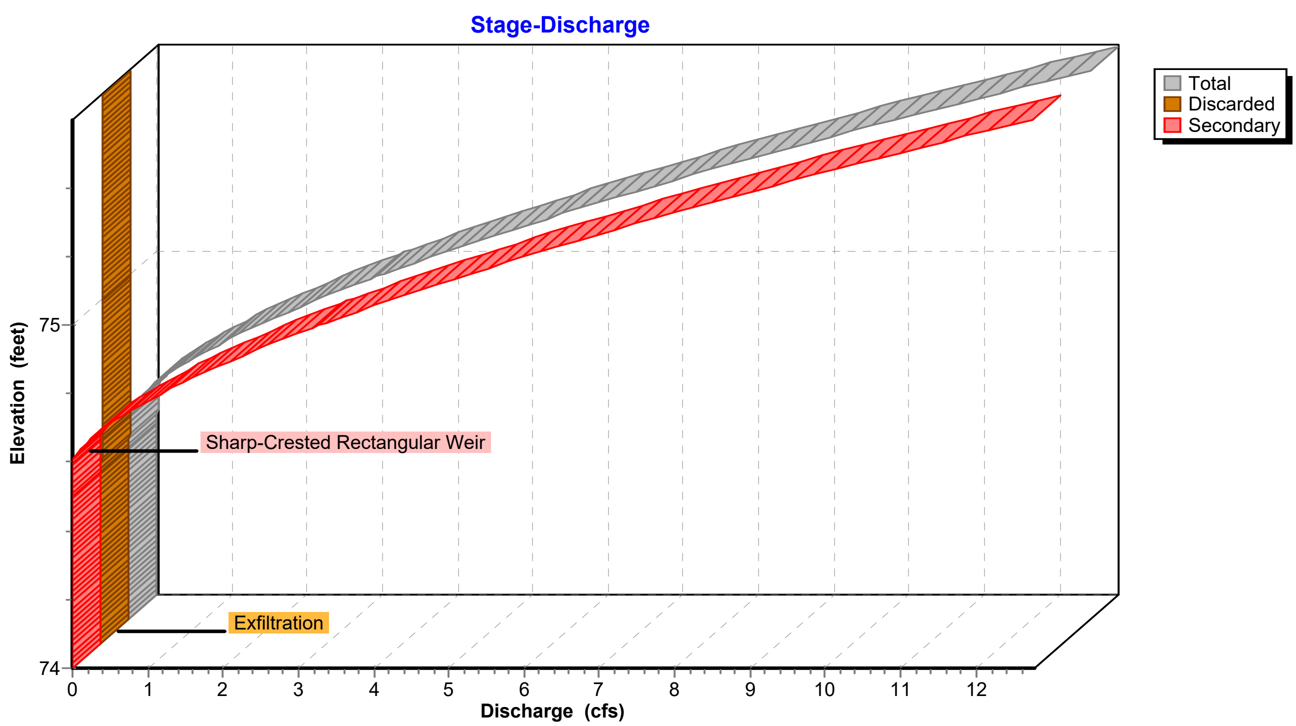
Discarded OutFlow Max=0.02 cfs @ 12.22 hrs HW=74.68' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Secondary OutFlow Max=0.30 cfs @ 12.22 hrs HW=74.68' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.30 cfs @ 0.93 fps)

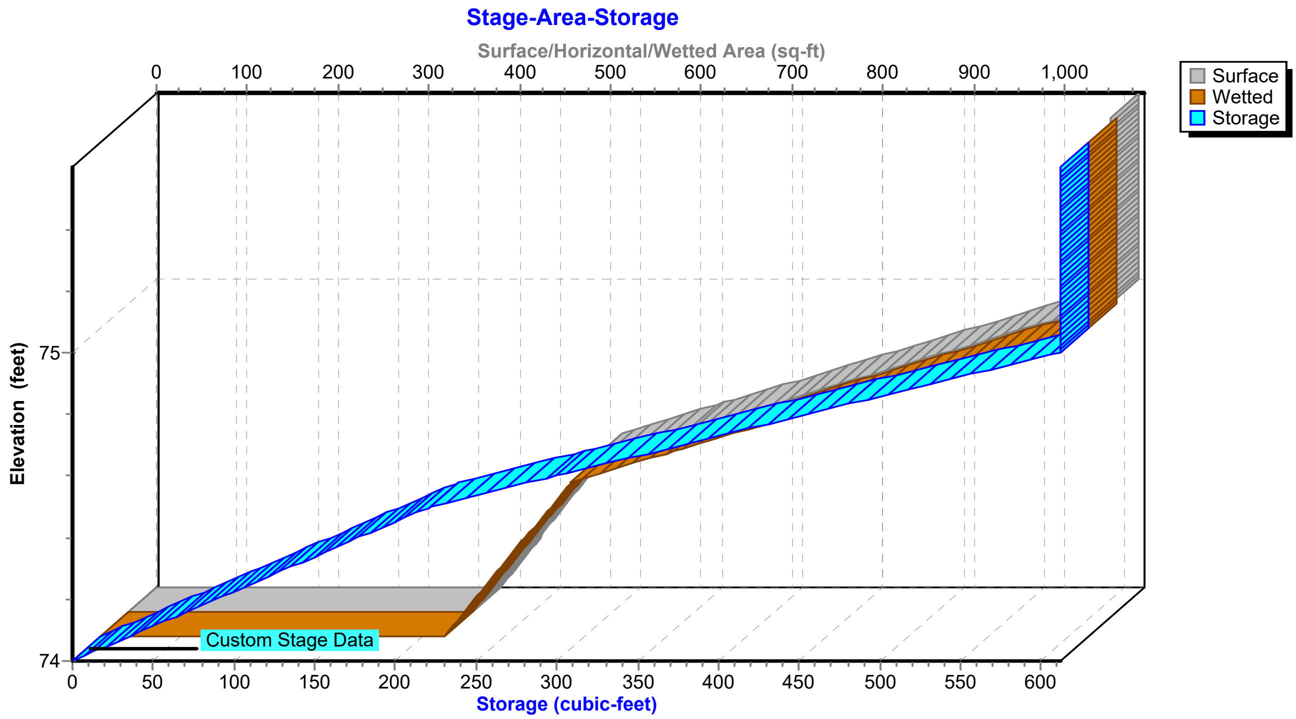
Pond 21P: Basin #2



Pond 21P: Basin #2



Pond 21P: Basin #2



Summary for Pond 25P: Subsurface infiltration

Inflow Area = 0.115 ac,100.00% Impervious, Inflow Depth = 3.17" for 2-Year event
Inflow = 0.33 cfs @ 12.14 hrs, Volume= 0.030 af
Outflow = 0.03 cfs @ 13.04 hrs, Volume= 0.030 af, Atten= 90%, Lag= 54.0 min
Discarded = 0.03 cfs @ 13.04 hrs, Volume= 0.030 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 81.47' @ 13.04 hrs Surf.Area= 0.008 ac Storage= 0.012 af

Plug-Flow detention time= 131.2 min calculated for 0.030 af (100% of inflow)
Center-of-Mass det. time= 131.2 min (890.0 - 758.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	79.00'	0.010 af	**10.80'W x 34.00'L x 5.50'H Field A** 0.046 af Overall - 0.022 af Embedded = 0.025 af x 40.0% Voids
#2A	80.00'	0.016 af	**Concrete Galley 4x4x4** x 16 Inside #1 Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf 2 Rows of 8 Chambers
		0.026 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	79.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	84.00'	**4.0" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=0.03 cfs @ 13.04 hrs HW=81.47' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=79.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Pond 25P: Subsurface infiltration - Chamber Wizard Field A

Chamber Model = Concrete Galley 4x4x4 (Concrete Galley, UCPI 4x4x4 Galley or equivalent)
Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf
Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf

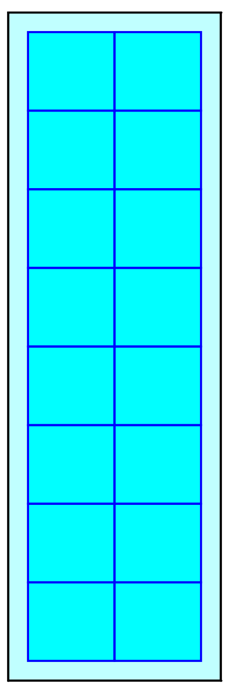
8 Chambers/Row x 4.00' Long = 32.00' Row Length +12.0" End Stone x 2 = 34.00' Base Length
2 Rows x 52.8" Wide + 12.0" Side Stone x 2 = 10.80' Base Width
12.0" Base + 48.0" Chamber Height + 6.0" Cover = 5.50' Field Height

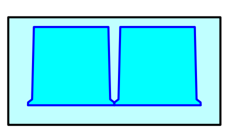
16 Chambers x 44.3 cf = 709.5 cf Chamber Storage
16 Chambers x 58.9 cf = 942.0 cf Displacement

2,019.6 cf Field - 942.0 cf Chambers = 1,077.6 cf Stone x 40.0% Voids = 431.0 cf Stone Storage

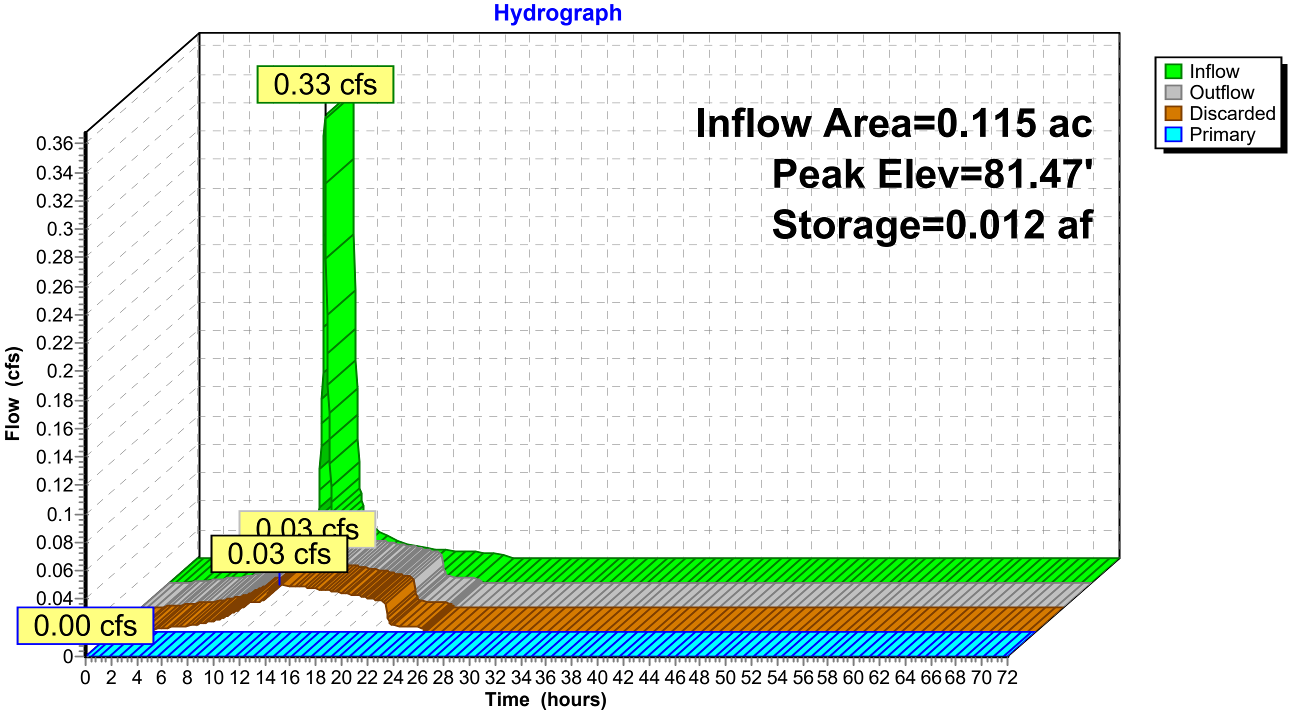
Chamber Storage + Stone Storage = 1,140.5 cf = 0.026 af
Overall Storage Efficiency = 56.5%
Overall System Size = 34.00' x 10.80' x 5.50'

16 Chambers @ $ 300.00 /ea = $ 4,800.00
74.8 cy Field Excavation @ $ 10.00 /cy = $ 748.00
39.9 cy Stone @ $ 30.00 /cy = $ 1,197.31
Total Cost = $ 6,745.31

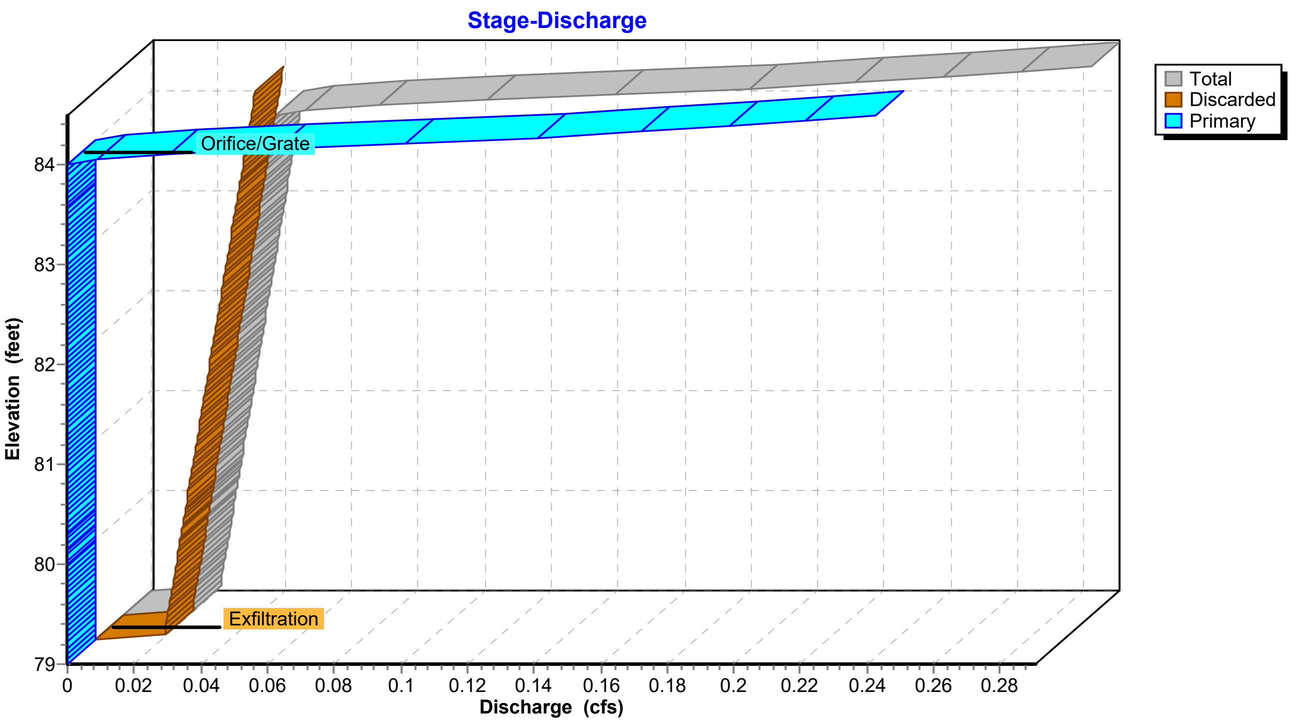




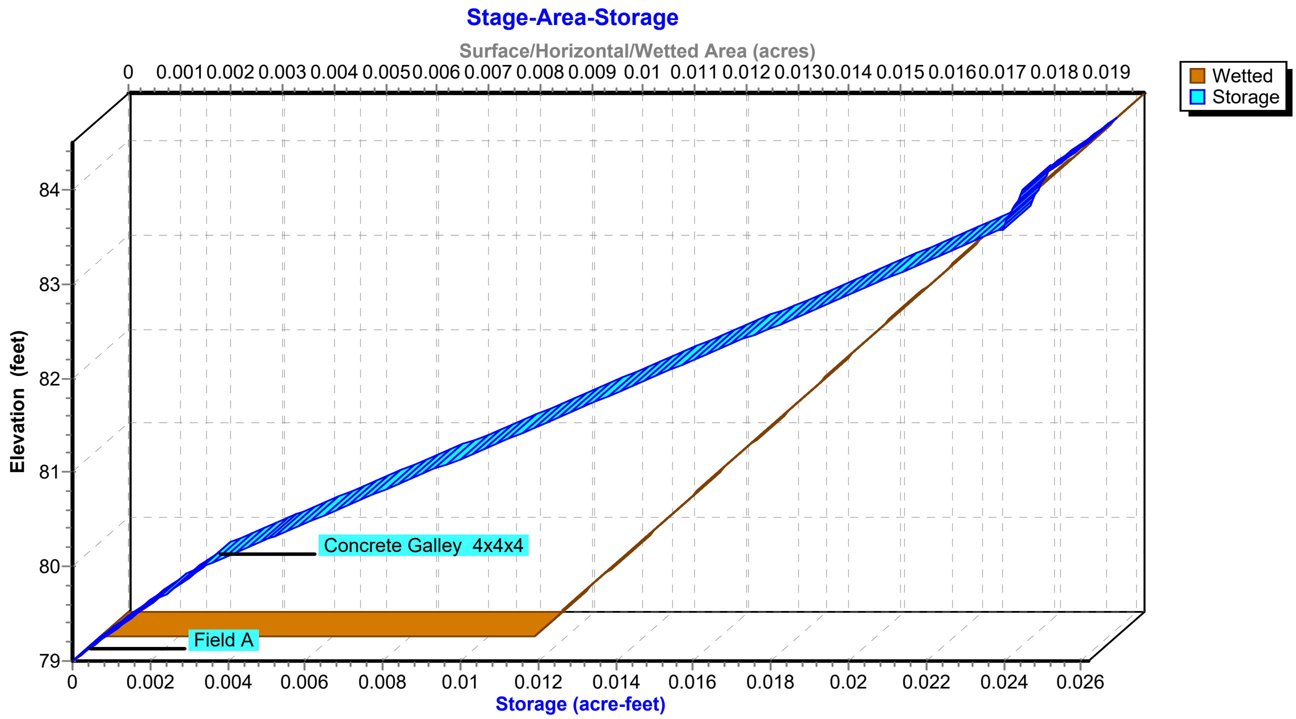
Pond 25P: Subsurface infiltration



Pond 25P: Subsurface infiltration



Pond 25P: Subsurface infiltration

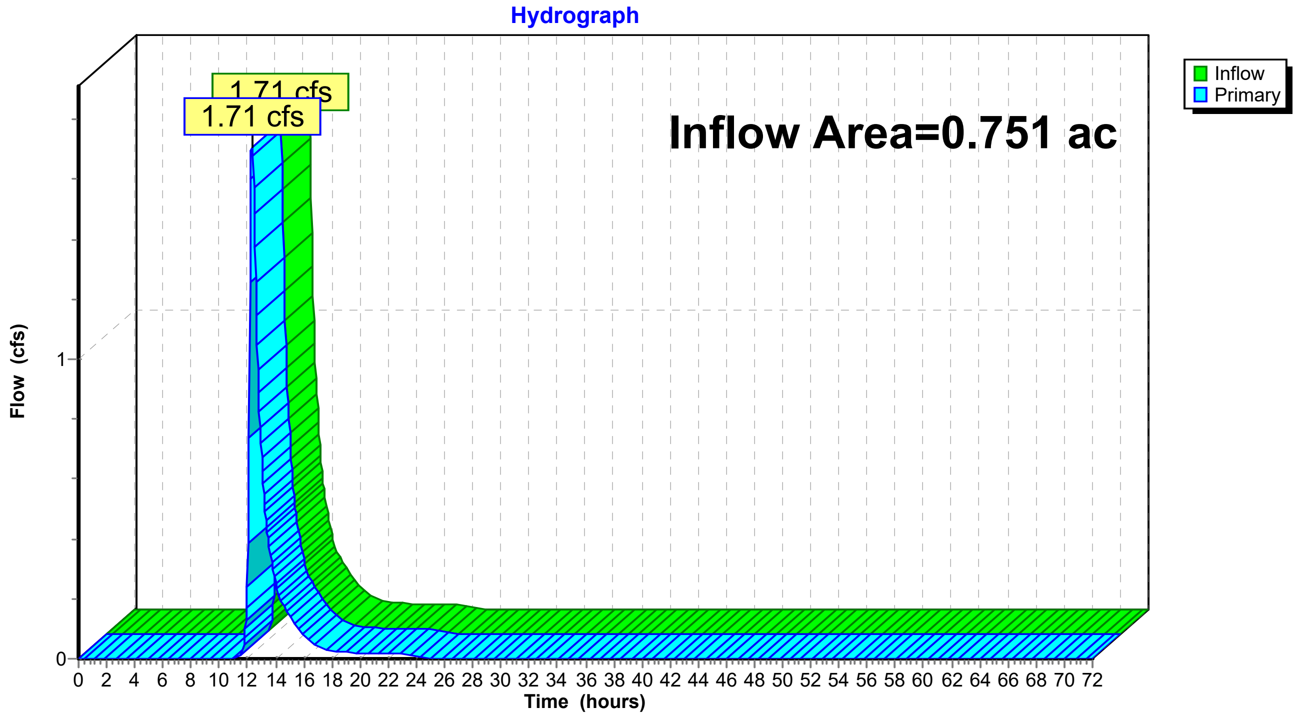


Summary for Link 23L: (Combined Link)

Inflow Area = 0.751 ac, 0.00% Impervious, Inflow Depth = 2.79" for 2-Year event
Inflow = 1.71 cfs @ 12.29 hrs, Volume= 0.175 af
Primary = 1.71 cfs @ 12.29 hrs, Volume= 0.175 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Link 23L: (Combined Link)



Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: POST (4) Runoff Area=33,810 sf 81.58% Impervious Runoff Depth=4.01"
Flow Length=298' Tc=10.0 min CN=94 Runoff=2.95 cfs 0.260 af

Subcatchment 15S: PRE (3) Runoff Area=97,629 sf 0.00% Impervious Runoff Depth=1.82"
Flow Length=382' Tc=10.0 min CN=70 Runoff=4.02 cfs 0.339 af

Subcatchment 16S: POST (7) Runoff Area=7,754 sf 57.09% Impervious Runoff Depth=3.38"
Flow Length=156' Slope=0.0500 '/' Tc=10.0 min CN=88 Runoff=0.60 cfs 0.050 af

Subcatchment 18S: POST (5) Runoff Area=5,000 sf 100.00% Impervious Runoff Depth=4.46"
Tc=10.0 min CN=98 Runoff=0.46 cfs 0.043 af

Subcatchment 19S: POST (6) Runoff Area=14,954 sf 0.00% Impervious Runoff Depth=2.13"
Flow Length=188' Tc=10.0 min CN=74 Runoff=0.73 cfs 0.061 af

Subcatchment 20S: POST (8) Runoff Area=32,707 sf 0.00% Impervious Runoff Depth=1.82"
Flow Length=134' Tc=10.0 min CN=70 Runoff=1.35 cfs 0.114 af

Subcatchment 26S: POST (4a) Runoff Area=7,416 sf 100.00% Impervious Runoff Depth=4.46"
Tc=10.0 min CN=98 Runoff=0.68 cfs 0.063 af

Pond 17P: Basin #1 Peak Elev=80.13' Storage=5,270 cf Inflow=4.36 cfs 0.384 af
Discarded=0.15 cfs 0.176 af Secondary=0.31 cfs 0.005 af Tertiary=2.02 cfs 0.202 af Outflow=2.48 cfs 0.384 af

Pond 21P: Basin #2 Peak Elev=74.72' Storage=395 cf Inflow=0.60 cfs 0.050 af
Discarded=0.02 cfs 0.023 af Secondary=0.56 cfs 0.027 af Outflow=0.57 cfs 0.050 af

Pond 25P: Subsurface infiltration Peak Elev=82.60' Storage=0.018 af Inflow=0.46 cfs 0.043 af
Discarded=0.04 cfs 0.043 af Primary=0.00 cfs 0.000 af Outflow=0.04 cfs 0.043 af

Link 23L: (Combined Link) Inflow=3.68 cfs 0.348 af
Primary=3.68 cfs 0.348 af

Total Runoff Area = 4.575 ac Runoff Volume = 0.930 af Average Runoff Depth = 2.44"
77.71% Pervious = 3.555 ac 22.29% Impervious = 1.020 ac

Summary for Subcatchment 13S: POST (4)

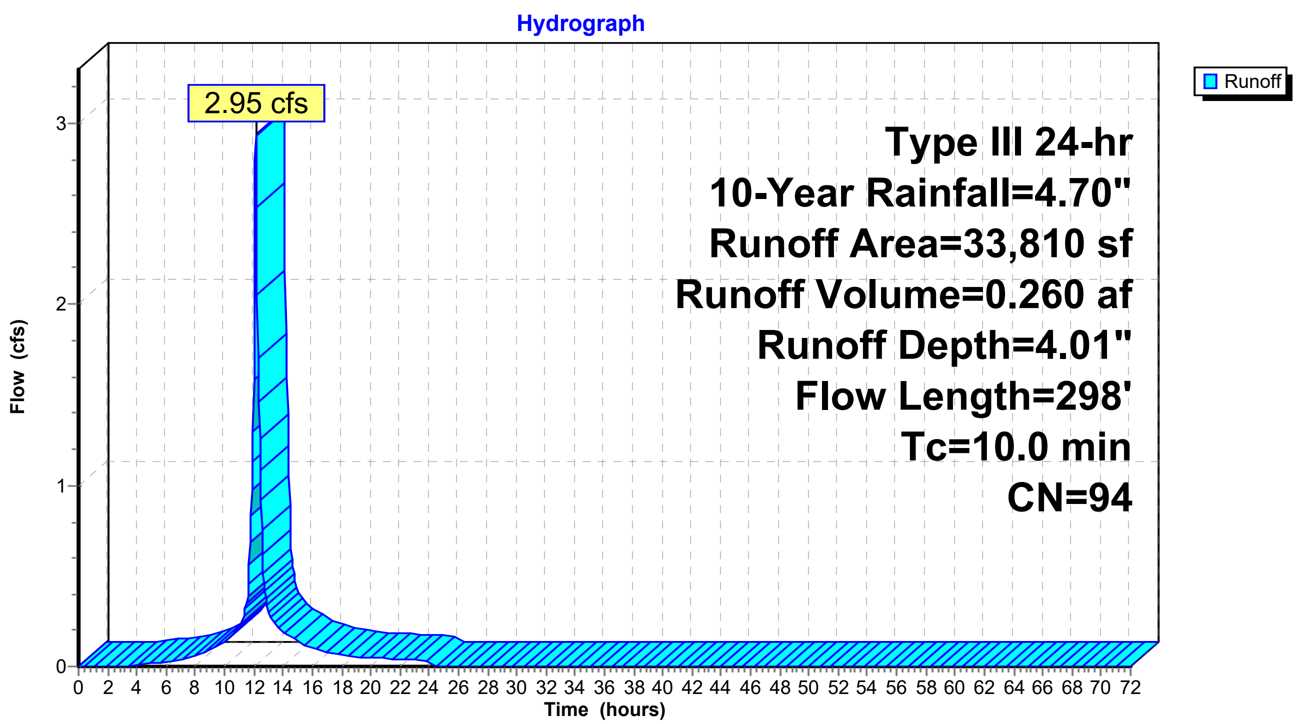
Runoff = 2.95 cfs @ 12.14 hrs, Volume= 0.260 af, Depth= 4.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
27,582	98	Paved parking, HSG C
1,469	70	Woods, Good, HSG C
4,759	79	50-75% Grass cover, Fair, HSG C
33,810	94	Weighted Average
6,228	77	18.42% Pervious Area
27,582	98	81.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	40	0.0500	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
0.1	10	0.0500	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
1.1	248	0.0370	3.90		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
8.1	298	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 13S: POST (4)



Summary for Subcatchment 15S: PRE (3)

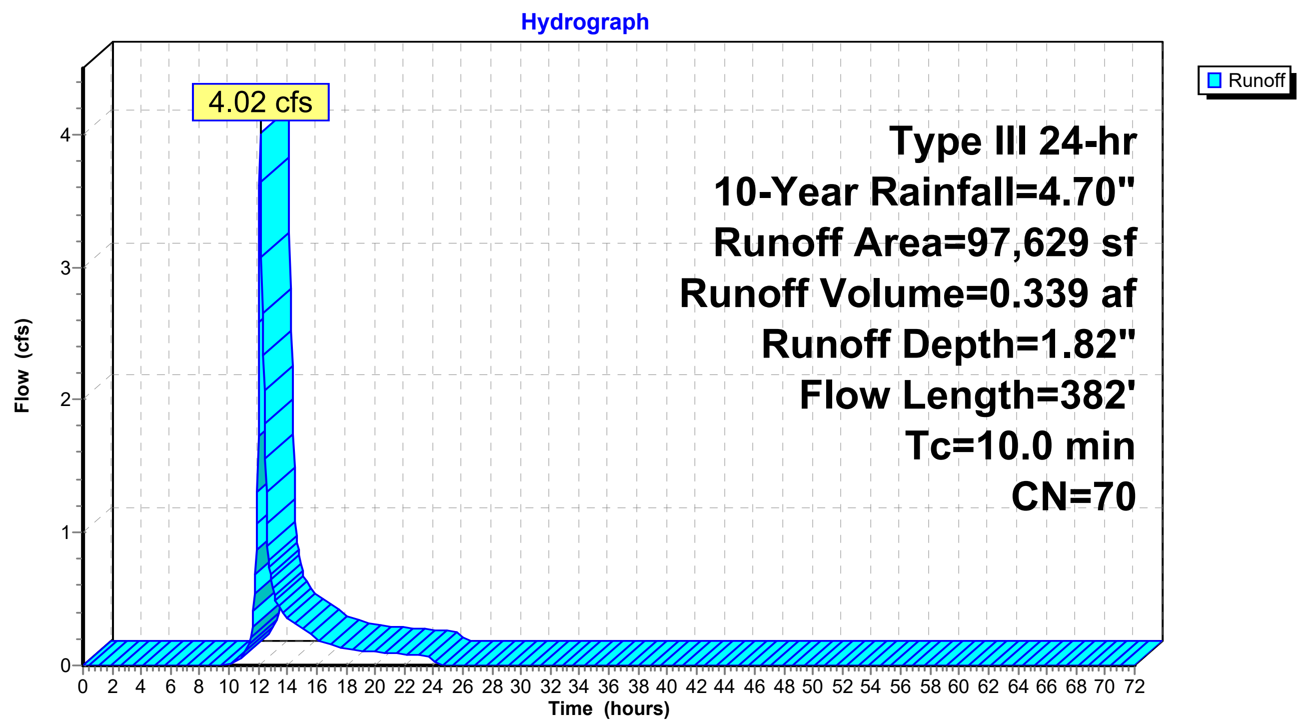
Runoff = 4.02 cfs @ 12.15 hrs, Volume= 0.339 af, Depth= 1.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
97,629	70	Woods, Good, HSG C
97,629	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
2.6	138	0.0320	0.89		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	146	0.0710	1.33		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.5	48	0.0850	1.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.7	382	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 15S: PRE (3)



Summary for Subcatchment 16S: POST (7)

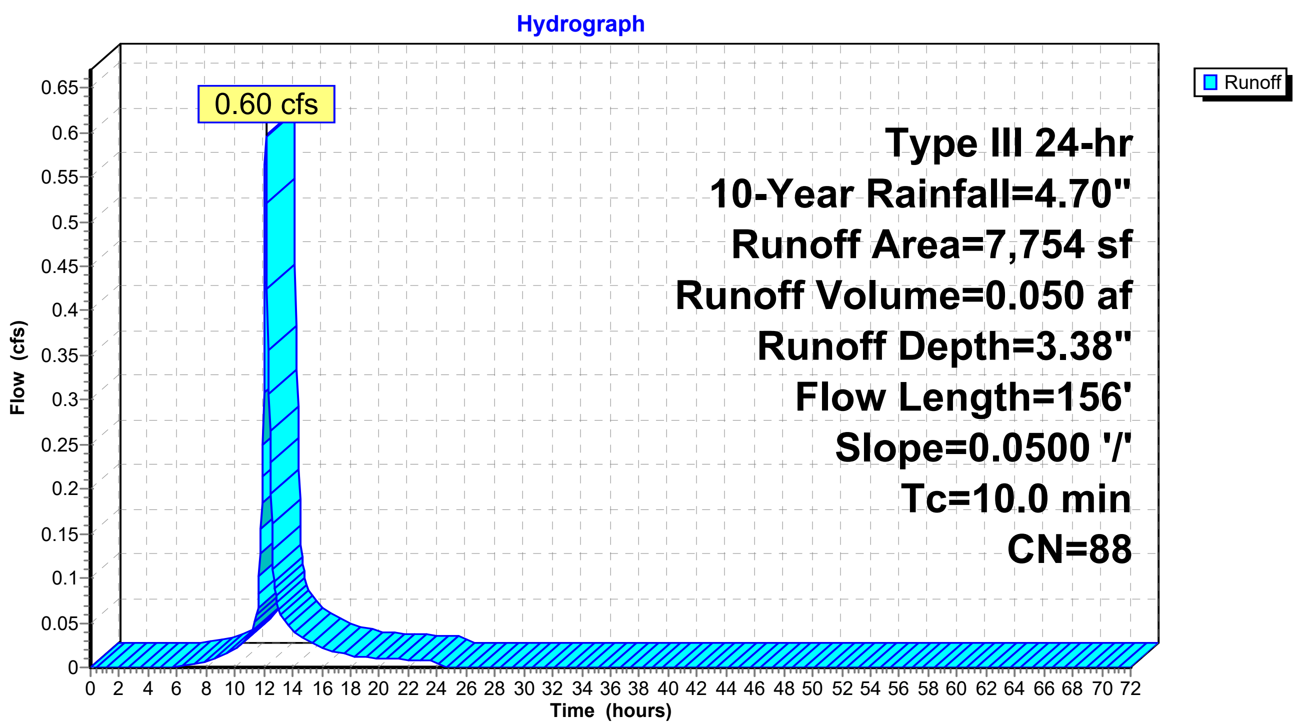
Runoff = 0.60 cfs @ 12.14 hrs, Volume= 0.050 af, Depth= 3.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
3,327	74	>75% Grass cover, Good, HSG C
4,427	98	Paved parking, HSG C
7,754	88	Weighted Average
3,327	74	42.91% Pervious Area
4,427	98	57.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	50	0.0500	1.78		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
0.4	106	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.9	156	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 16S: POST (7)



Summary for Subcatchment 18S: POST (5)

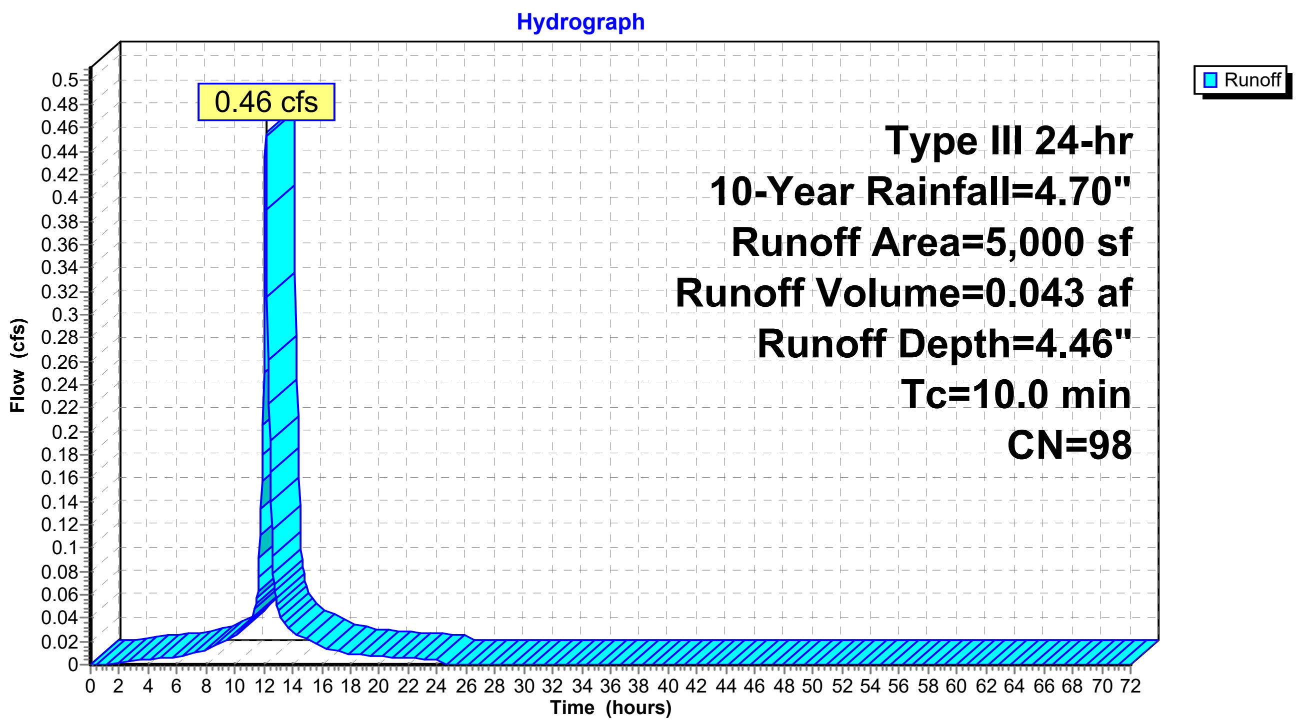
Runoff = 0.46 cfs @ 12.14 hrs, Volume= 0.043 af, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,000	98	Roofs, HSG C
5,000	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Estimate**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 18S: POST (5)



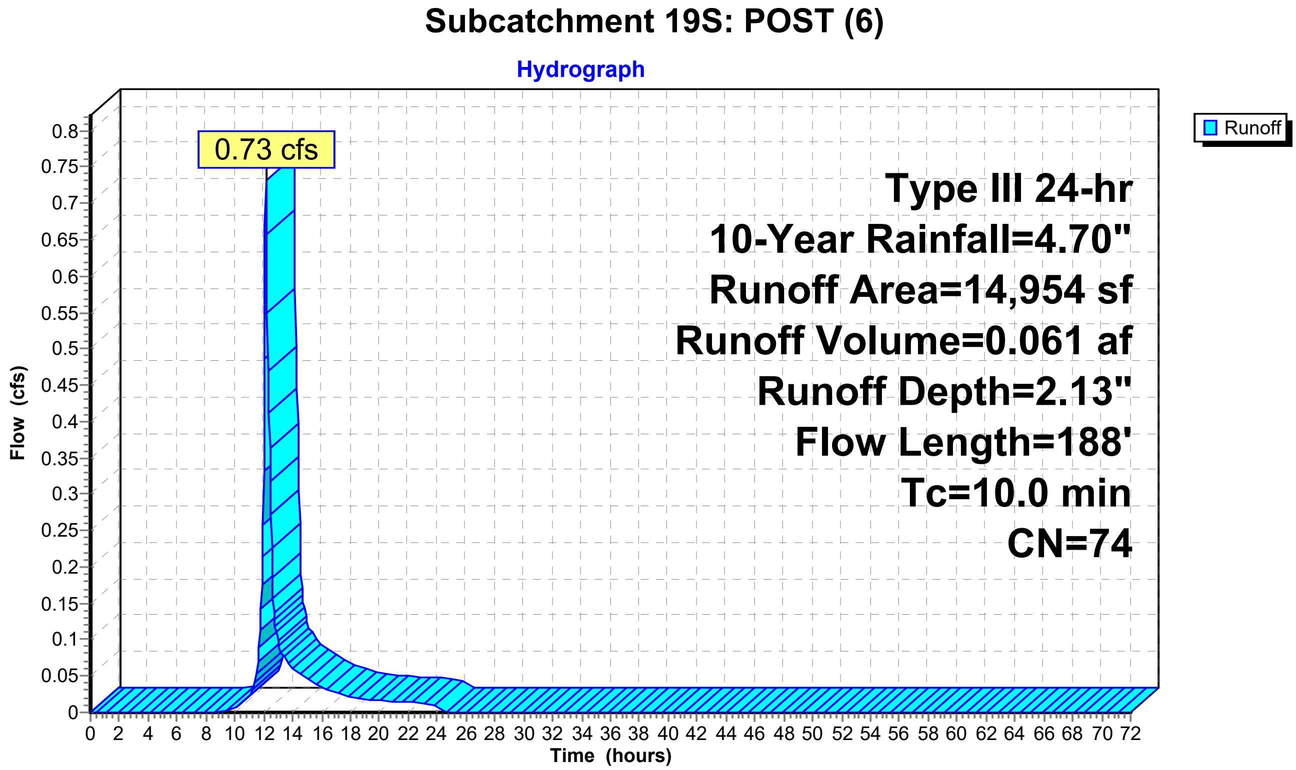
Summary for Subcatchment 19S: POST (6)

Runoff = 0.73 cfs @ 12.15 hrs, Volume= 0.061 af, Depth= 2.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
14,954	74	>75% Grass cover, Good, HSG C
14,954	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.40"
1.2	102	0.0400	1.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	36	0.3300	4.02		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.3	188	Total, Increased to minimum Tc = 10.0 min			



Summary for Subcatchment 20S: POST (8)

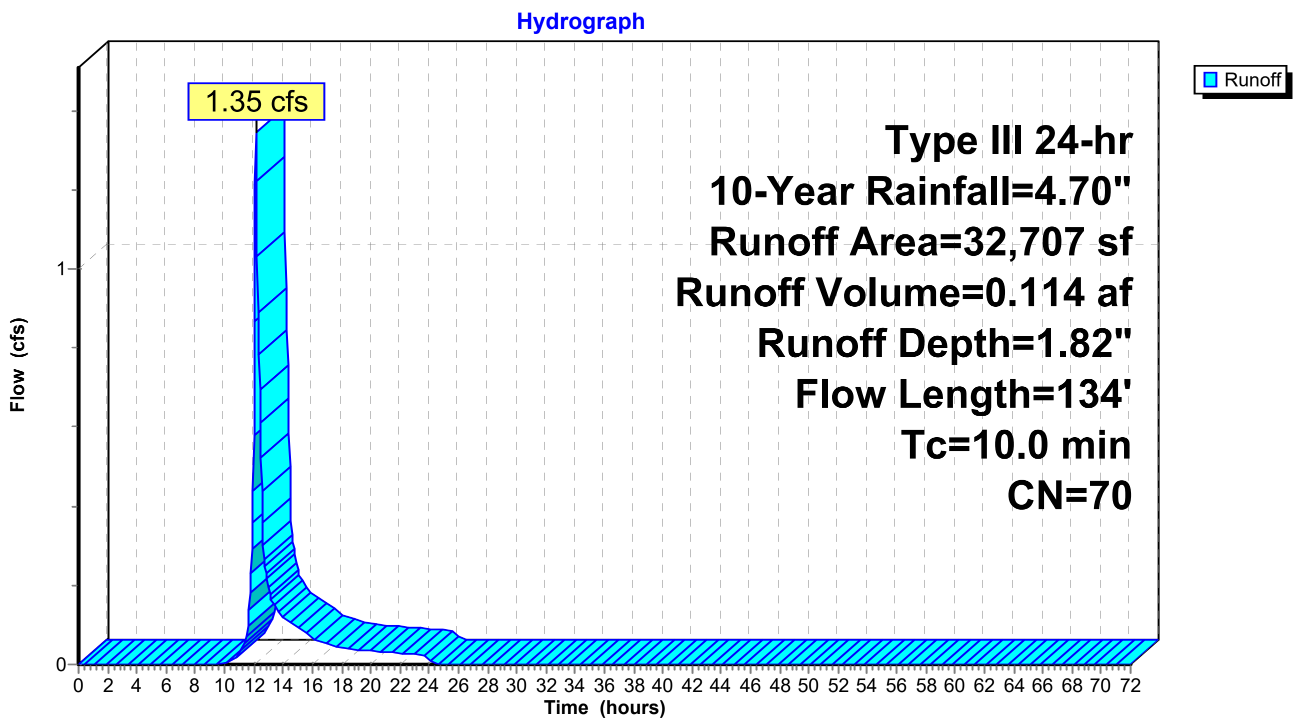
Runoff = 1.35 cfs @ 12.15 hrs, Volume= 0.114 af, Depth= 1.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
1,400	74	>75% Grass cover, Good, HSG C
31,307	70	Woods, Good, HSG C
32,707	70	Weighted Average
32,707	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0800	0.12		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
1.1	84	0.0700	1.32		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.0	134	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 20S: POST (8)



Summary for Subcatchment 26S: POST (4a)

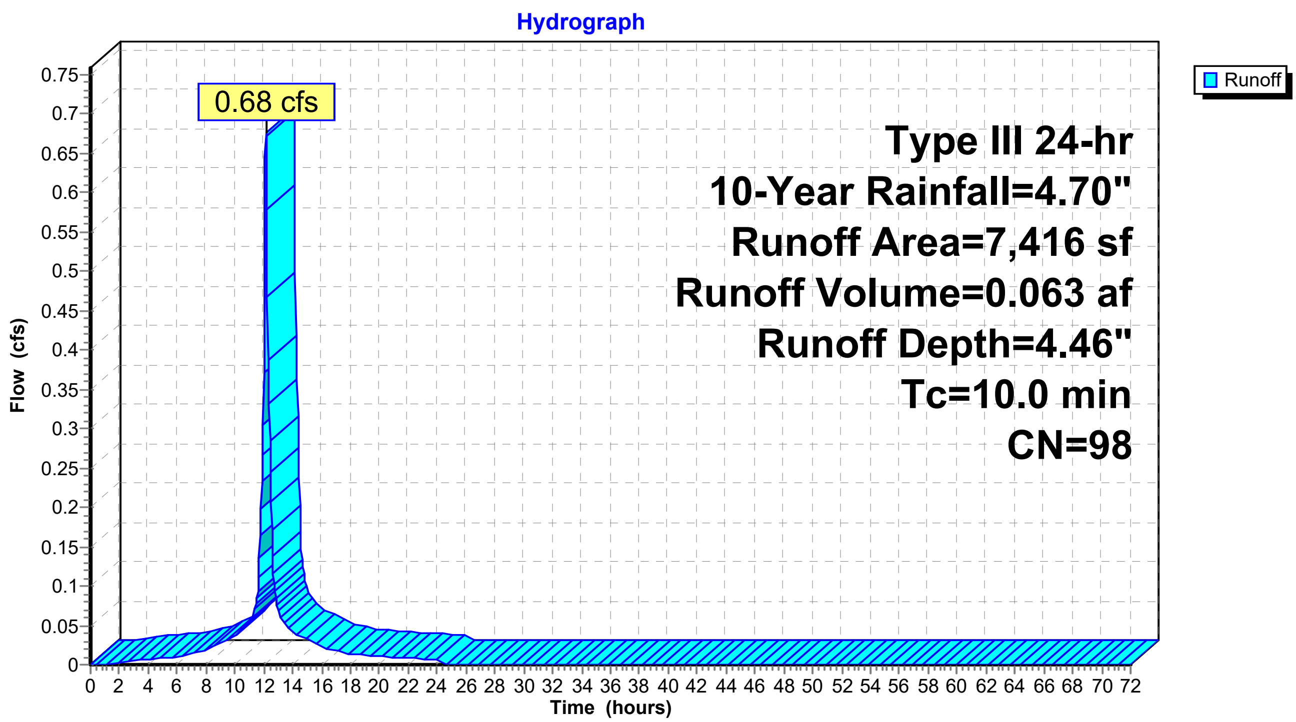
Runoff = 0.68 cfs @ 12.14 hrs, Volume= 0.063 af, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
7,416	98	Paved parking, HSG C
7,416	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Tc 4A**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 26S: POST (4a)



Summary for Pond 17P: Basin #1

Inflow Area = 1.404 ac, 65.38% Impervious, Inflow Depth = 3.28" for 10-Year event
Inflow = 4.36 cfs @ 12.14 hrs, Volume= 0.384 af
Outflow = 2.48 cfs @ 12.32 hrs, Volume= 0.384 af, Atten= 43%, Lag= 10.7 min
Discarded = 0.15 cfs @ 12.32 hrs, Volume= 0.176 af
Secondary = 0.31 cfs @ 12.32 hrs, Volume= 0.005 af
Tertiary = 2.02 cfs @ 12.32 hrs, Volume= 0.202 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 80.13' @ 12.32 hrs Surf.Area= 2,689 sf Storage= 5,270 cf

Plug-Flow detention time= 146.6 min calculated for 0.384 af (100% of inflow)
Center-of-Mass det. time= 146.4 min (931.4 - 785.0)

Volume	Invert	Avail.Storage	Storage Description
#1	77.00'	11,397 cf	**Custom Stage Data (Conic)** Listed below

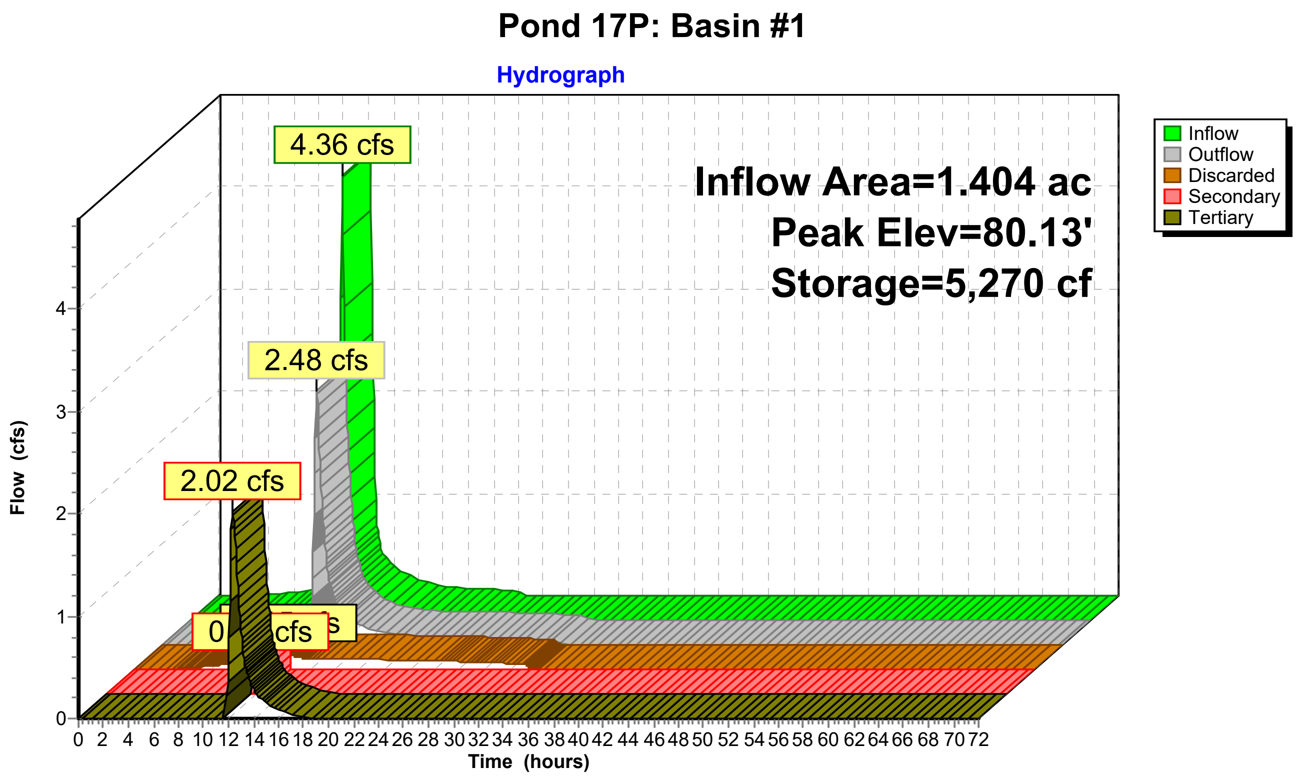
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
77.00	934	0	0	934
78.00	1,344	1,133	1,133	1,361
79.00	1,810	1,571	2,704	1,848
80.00	2,609	2,197	4,901	2,664
81.00	3,239	2,918	7,820	3,322
82.00	3,926	3,577	11,397	4,041

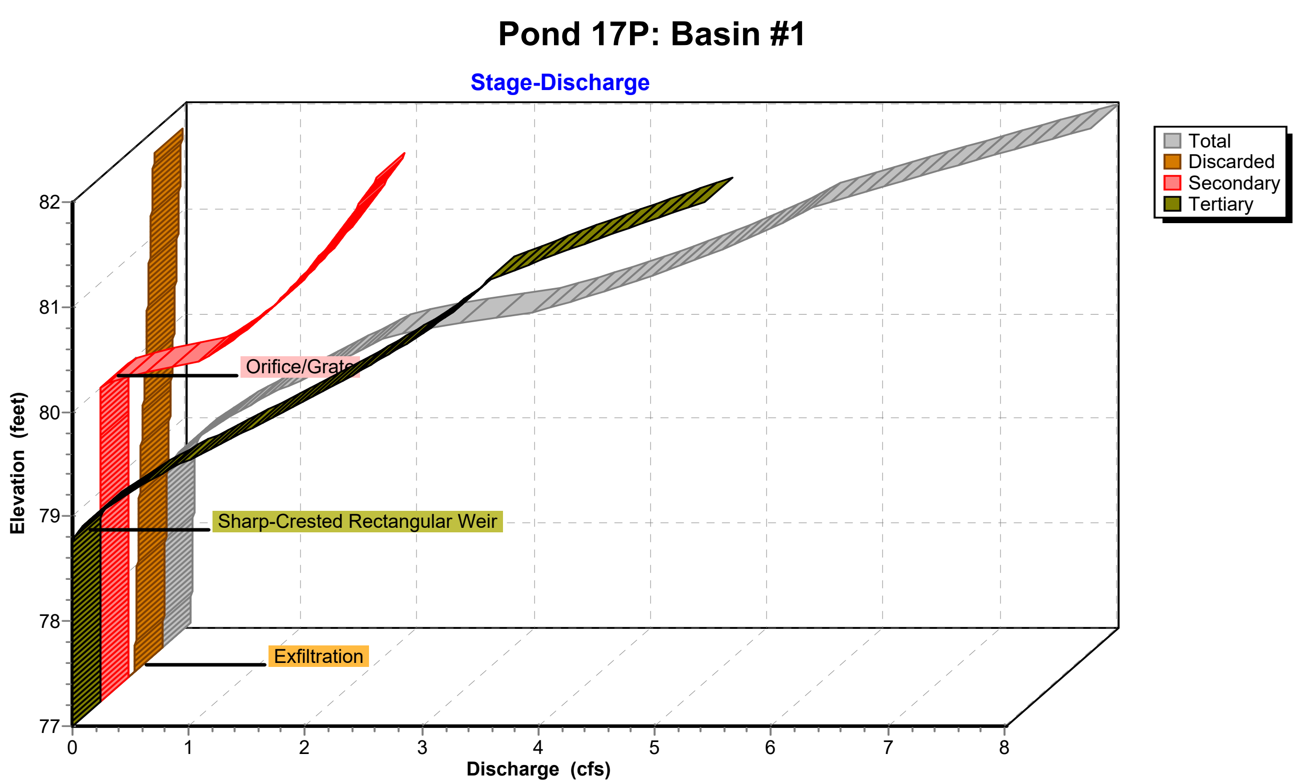
Device	Routing	Invert	Outlet Devices
#1	Discarded	77.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Secondary	80.00'	**8.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	78.75'	**0.5' long Sharp-Crested Rectangular Weir** 1 End Contraction(s) 3.0' Crest Height

Discarded OutFlow Max=0.15 cfs @ 12.32 hrs HW=80.12' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.15 cfs)

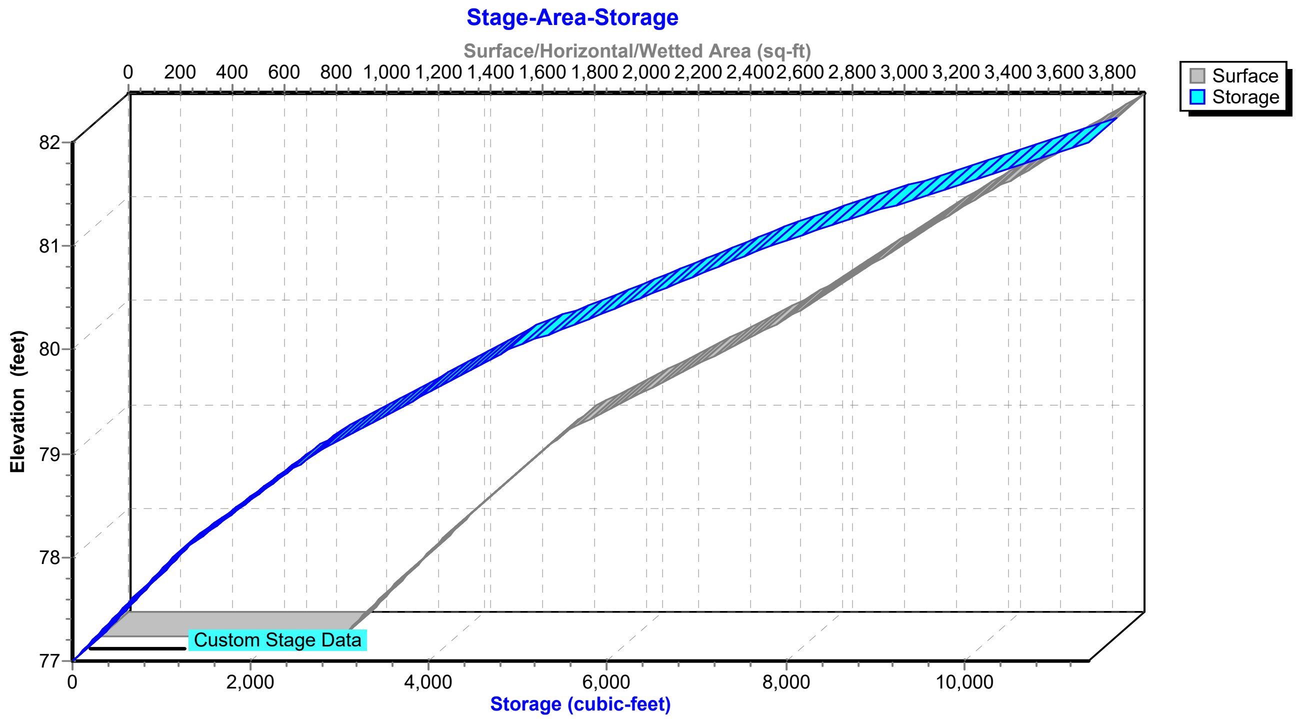
Secondary OutFlow Max=0.29 cfs @ 12.32 hrs HW=80.12' (Free Discharge)
└─**2=Orifice/Grate** (Weir Controls 0.29 cfs @ 1.15 fps)

Tertiary OutFlow Max=2.01 cfs @ 12.32 hrs HW=80.12' (Free Discharge)
└─**3=Sharp-Crested Rectangular Weir** (Weir Controls 2.01 cfs @ 4.05 fps)


Pond 17P: Basin #1
Hydrograph
4.36 cfs
2.48 cfs
2.02 cfs
Inflow Area=1.404 ac
Peak Elev=80.13'
Storage=5,270 cf
Inflow
Outflow
Discarded
Secondary
Tertiary
Flow (cfs)
Time (hours)


Pond 17P: Basin #1
Stage-Discharge
Total
Discarded
Secondary
Tertiary
Orifice/Grate
Sharp-Crested Rectangular Weir
Exfiltration
Elevation (feet)
Discharge (cfs)

Pond 17P: Basin #1



Summary for Pond 21P: Basin #2

Inflow Area = 0.178 ac, 57.09% Impervious, Inflow Depth = 3.38" for 10-Year event
Inflow = 0.60 cfs @ 12.14 hrs, Volume= 0.050 af
Outflow = 0.57 cfs @ 12.17 hrs, Volume= 0.050 af, Atten= 4%, Lag= 1.9 min
Discarded = 0.02 cfs @ 12.17 hrs, Volume= 0.023 af
Secondary = 0.56 cfs @ 12.17 hrs, Volume= 0.027 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 74.72' @ 12.17 hrs Surf.Area= 765 sf Storage= 395 cf

Plug-Flow detention time= 118.6 min calculated for 0.050 af (100% of inflow)
Center-of-Mass det. time= 118.7 min (922.6 - 803.8)

Volume	Invert	Avail.Storage	Storage Description
#1	74.00'	612 cf	**Custom Stage Data (Conic)** Listed below

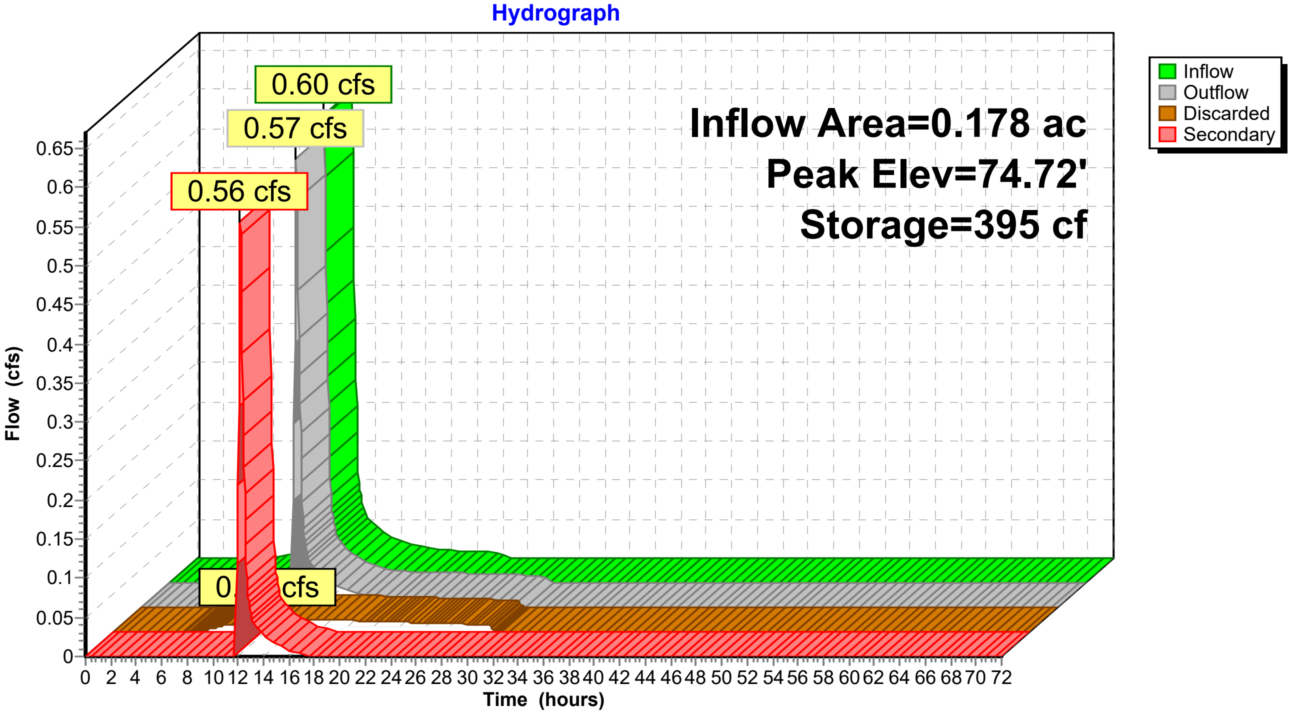
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
74.00	379	0	0	379
74.50	513	222	222	518
75.00	1,081	390	612	1,088

Device	Routing	Invert	Outlet Devices
#1	Discarded	74.00'	**1.020 in/hr Exfiltration over Wetted area**
#2	Secondary	74.60'	**4.0' long x 1.00' rise Sharp-Crested Rectangular Weir** 1 End Contraction(s)

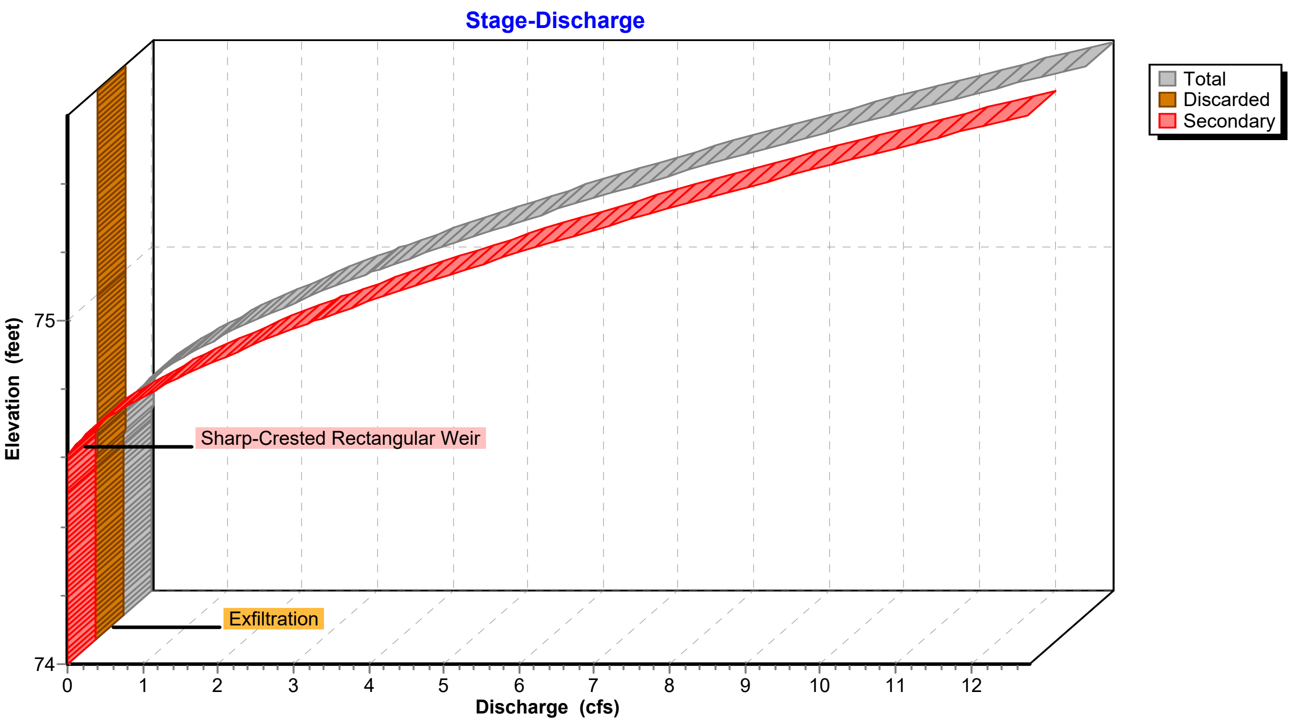
Discarded OutFlow Max=0.02 cfs @ 12.17 hrs HW=74.72' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Secondary OutFlow Max=0.54 cfs @ 12.17 hrs HW=74.72' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.54 cfs @ 1.13 fps)

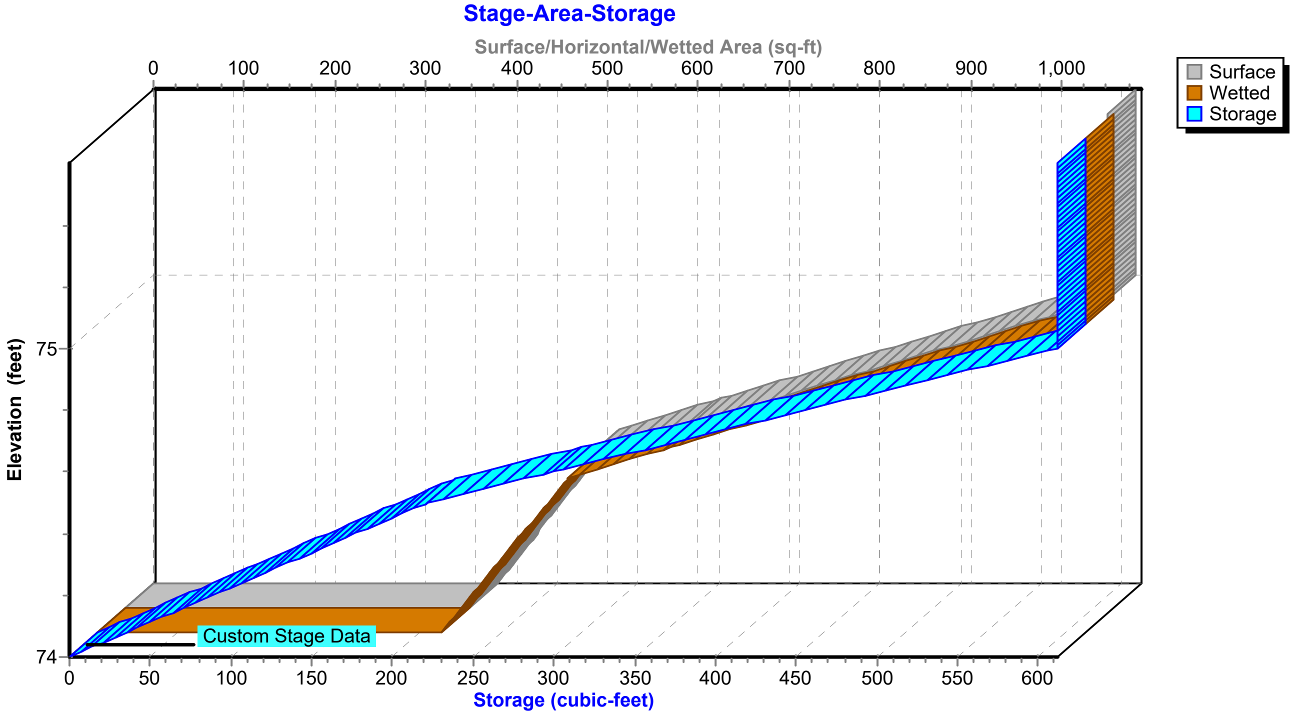
Pond 21P: Basin #2



Pond 21P: Basin #2



Pond 21P: Basin #2



Summary for Pond 25P: Subsurface infiltration

Inflow Area = 0.115 ac,100.00% Impervious, Inflow Depth = 4.46" for 10-Year event
Inflow = 0.46 cfs @ 12.14 hrs, Volume= 0.043 af
Outflow = 0.04 cfs @ 13.26 hrs, Volume= 0.043 af, Atten= 92%, Lag= 67.3 min
Discarded = 0.04 cfs @ 13.26 hrs, Volume= 0.043 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 82.60' @ 13.26 hrs Surf.Area= 0.008 ac Storage= 0.018 af

Plug-Flow detention time= 191.1 min calculated for 0.043 af (100% of inflow)
Center-of-Mass det. time= 191.0 min (943.8 - 752.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	79.00'	0.010 af	**10.80'W x 34.00'L x 5.50'H Field A** 0.046 af Overall - 0.022 af Embedded = 0.025 af x 40.0% Voids
#2A	80.00'	0.016 af	**Concrete Galley 4x4x4** x 16 Inside #1 Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf 2 Rows of 8 Chambers
		0.026 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	79.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	84.00'	**4.0" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=0.04 cfs @ 13.26 hrs HW=82.60' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=79.00' (Free Discharge)
↑—**2=Orifice/Grate** (Controls 0.00 cfs)

Pond 25P: Subsurface infiltration - Chamber Wizard Field A

Chamber Model = Concrete Galley 4x4x4 (Concrete Galley, UCPI 4x4x4 Galley or equivalent)
Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf
Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf

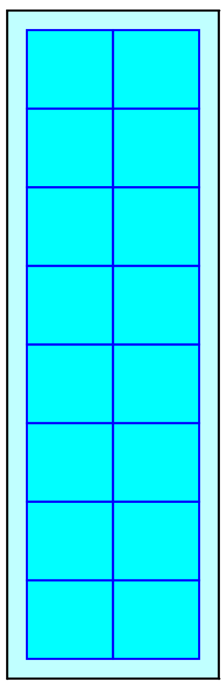
8 Chambers/Row x 4.00' Long = 32.00' Row Length +12.0" End Stone x 2 = 34.00' Base Length
2 Rows x 52.8" Wide + 12.0" Side Stone x 2 = 10.80' Base Width
12.0" Base + 48.0" Chamber Height + 6.0" Cover = 5.50' Field Height

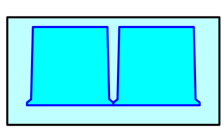
16 Chambers x 44.3 cf = 709.5 cf Chamber Storage
16 Chambers x 58.9 cf = 942.0 cf Displacement

2,019.6 cf Field - 942.0 cf Chambers = 1,077.6 cf Stone x 40.0% Voids = 431.0 cf Stone Storage

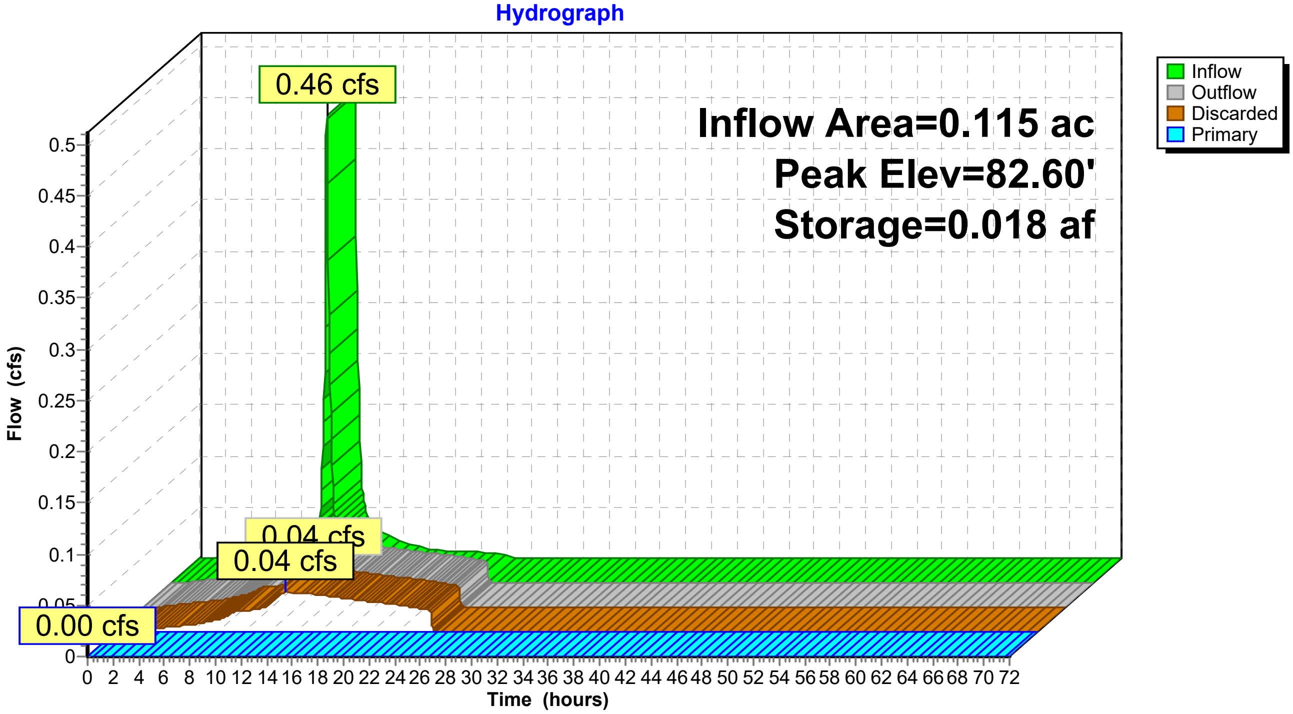
Chamber Storage + Stone Storage = 1,140.5 cf = 0.026 af
Overall Storage Efficiency = 56.5%
Overall System Size = 34.00' x 10.80' x 5.50'

16 Chambers @ $ 300.00 /ea = $ 4,800.00
74.8 cy Field Excavation @ $ 10.00 /cy = $ 748.00
39.9 cy Stone @ $ 30.00 /cy = $ 1,197.31
Total Cost = $ 6,745.31

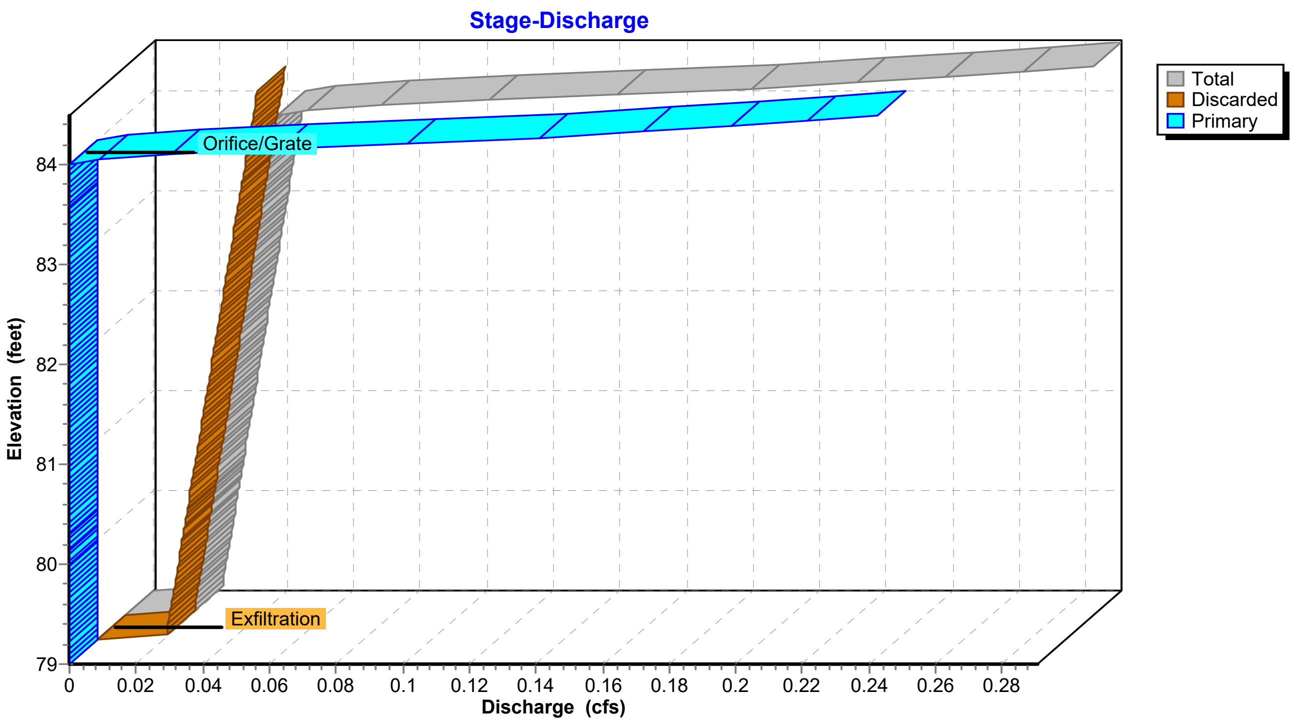




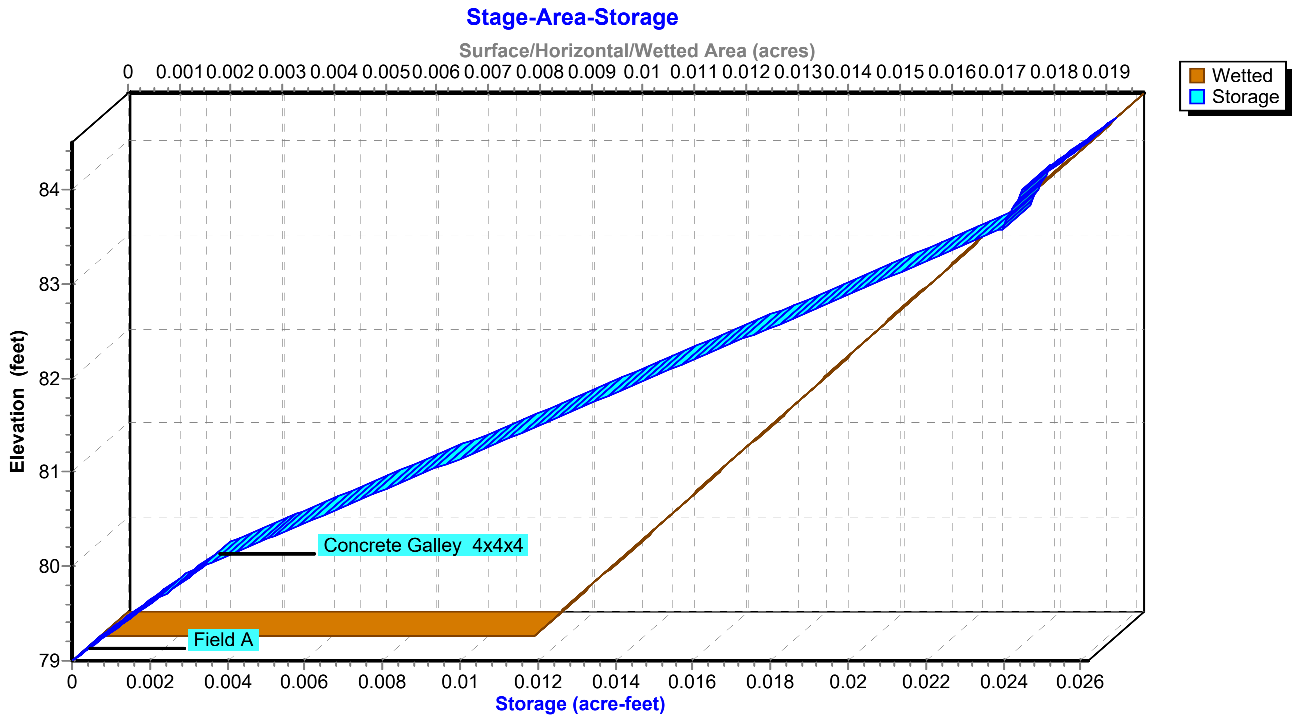
Pond 25P: Subsurface infiltration



Pond 25P: Subsurface infiltration



Pond 25P: Subsurface infiltration

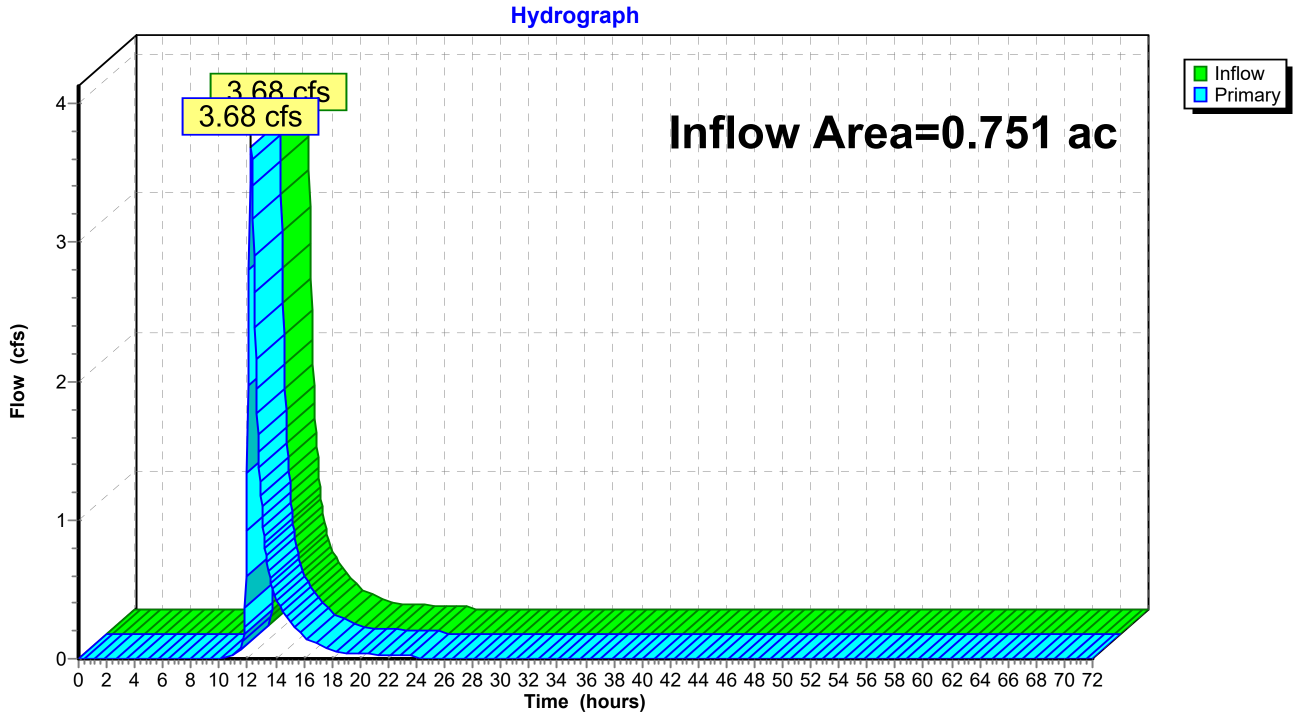


Summary for Link 23L: (Combined Link)

Inflow Area = 0.751 ac, 0.00% Impervious, Inflow Depth = 5.56" for 10-Year event
Inflow = 3.68 cfs @ 12.24 hrs, Volume= 0.348 af
Primary = 3.68 cfs @ 12.24 hrs, Volume= 0.348 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Link 23L: (Combined Link)



Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: POST (4) Runoff Area=33,810 sf 81.58% Impervious Runoff Depth=4.90"
Flow Length=298' Tc=10.0 min CN=94 Runoff=3.56 cfs 0.317 af

Subcatchment 15S: PRE (3) Runoff Area=97,629 sf 0.00% Impervious Runoff Depth=2.49"
Flow Length=382' Tc=10.0 min CN=70 Runoff=5.60 cfs 0.465 af

Subcatchment 16S: POST (7) Runoff Area=7,754 sf 57.09% Impervious Runoff Depth=4.24"
Flow Length=156' Slope=0.0500 '/' Tc=10.0 min CN=88 Runoff=0.74 cfs 0.063 af

Subcatchment 18S: POST (5) Runoff Area=5,000 sf 100.00% Impervious Runoff Depth=5.36"
Tc=10.0 min CN=98 Runoff=0.54 cfs 0.051 af

Subcatchment 19S: POST (6) Runoff Area=14,954 sf 0.00% Impervious Runoff Depth=2.85"
Flow Length=188' Tc=10.0 min CN=74 Runoff=0.99 cfs 0.082 af

Subcatchment 20S: POST (8) Runoff Area=32,707 sf 0.00% Impervious Runoff Depth=2.49"
Flow Length=134' Tc=10.0 min CN=70 Runoff=1.87 cfs 0.156 af

Subcatchment 26S: POST (4a) Runoff Area=7,416 sf 100.00% Impervious Runoff Depth=5.36"
Tc=10.0 min CN=98 Runoff=0.81 cfs 0.076 af

Pond 17P: Basin #1 Peak Elev=80.33' Storage=5,864 cf Inflow=5.36 cfs 0.475 af
Discarded=0.16 cfs 0.189 af Secondary=0.96 cfs 0.025 af Tertiary=2.36 cfs 0.260 af Outflow=3.49 cfs 0.475 af

Pond 21P: Basin #2 Peak Elev=74.74' Storage=411 cf Inflow=0.74 cfs 0.063 af
Discarded=0.02 cfs 0.025 af Secondary=0.70 cfs 0.038 af Outflow=0.72 cfs 0.063 af

Pond 25P: Subsurface infiltration Peak Elev=83.44' Storage=0.023 af Inflow=0.54 cfs 0.051 af
Discarded=0.04 cfs 0.051 af Primary=0.00 cfs 0.000 af Outflow=0.04 cfs 0.051 af

Link 23L: (Combined Link) Inflow=5.52 cfs 0.479 af
Primary=5.52 cfs 0.479 af

Total Runoff Area = 4.575 ac Runoff Volume = 1.210 af Average Runoff Depth = 3.17"
77.71% Pervious = 3.555 ac 22.29% Impervious = 1.020 ac

Summary for Subcatchment 13S: POST (4)

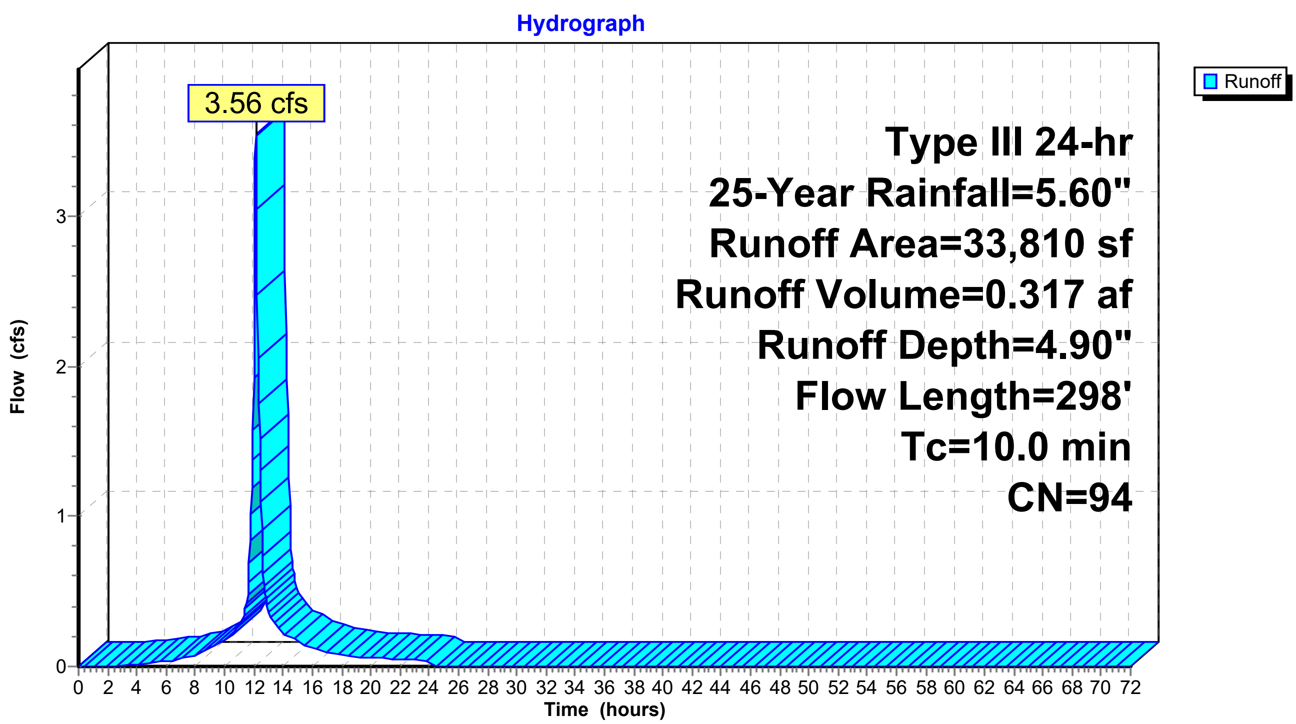
Runoff = 3.56 cfs @ 12.14 hrs, Volume= 0.317 af, Depth= 4.90"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
27,582	98	Paved parking, HSG C
1,469	70	Woods, Good, HSG C
4,759	79	50-75% Grass cover, Fair, HSG C
33,810	94	Weighted Average
6,228	77	18.42% Pervious Area
27,582	98	81.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	40	0.0500	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
0.1	10	0.0500	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
1.1	248	0.0370	3.90		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
8.1	298	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 13S: POST (4)



Summary for Subcatchment 15S: PRE (3)

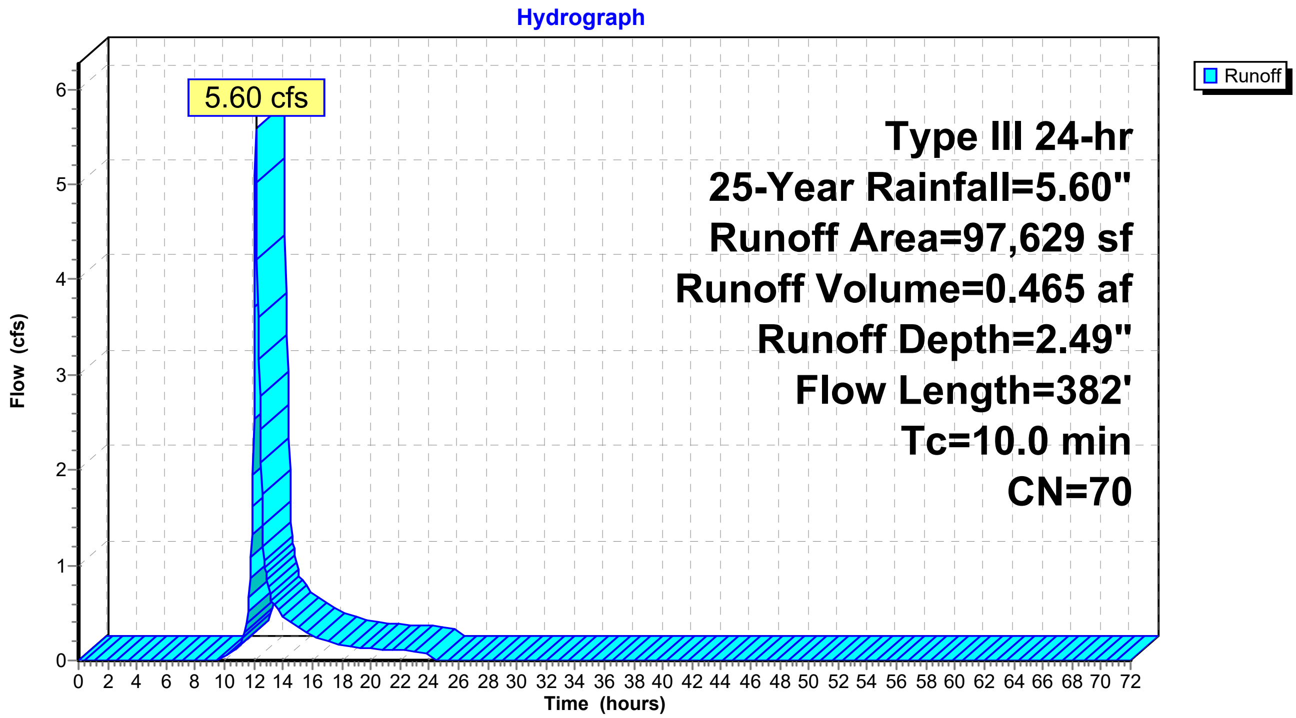
Runoff = 5.60 cfs @ 12.15 hrs, Volume= 0.465 af, Depth= 2.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
97,629	70	Woods, Good, HSG C
97,629	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
2.6	138	0.0320	0.89		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	146	0.0710	1.33		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.5	48	0.0850	1.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.7	382	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 15S: PRE (3)



Summary for Subcatchment 16S: POST (7)

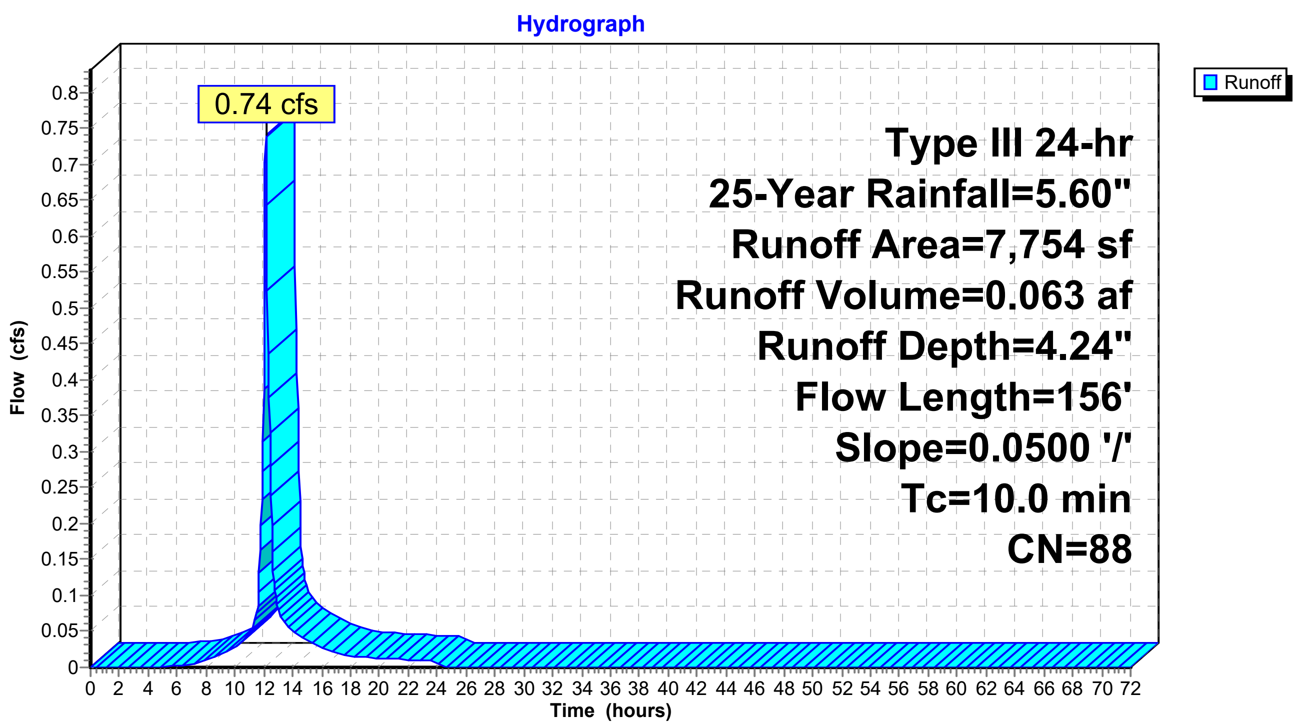
Runoff = 0.74 cfs @ 12.14 hrs, Volume= 0.063 af, Depth= 4.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
3,327	74	>75% Grass cover, Good, HSG C
4,427	98	Paved parking, HSG C
7,754	88	Weighted Average
3,327	74	42.91% Pervious Area
4,427	98	57.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	50	0.0500	1.78		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
0.4	106	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.9	156	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 16S: POST (7)



Summary for Subcatchment 18S: POST (5)

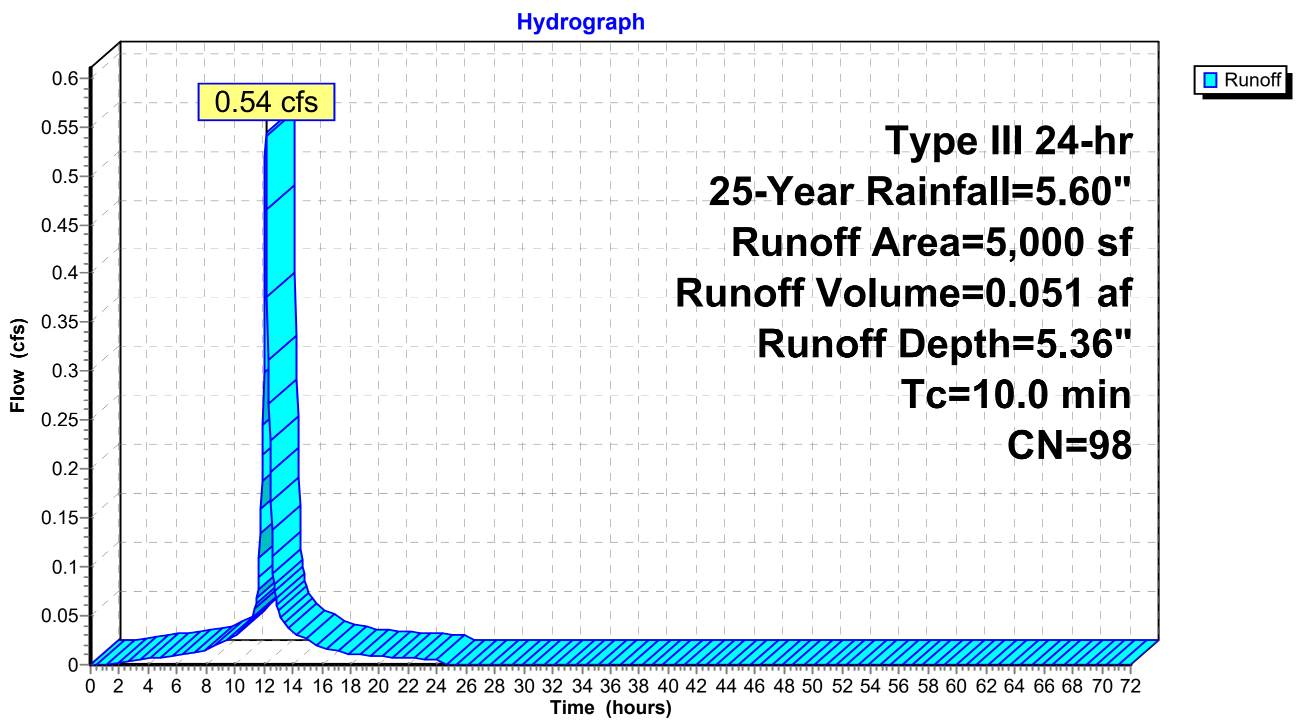
Runoff = 0.54 cfs @ 12.14 hrs, Volume= 0.051 af, Depth= 5.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
5,000	98	Roofs, HSG C
5,000	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Estimate**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 18S: POST (5)



Summary for Subcatchment 19S: POST (6)

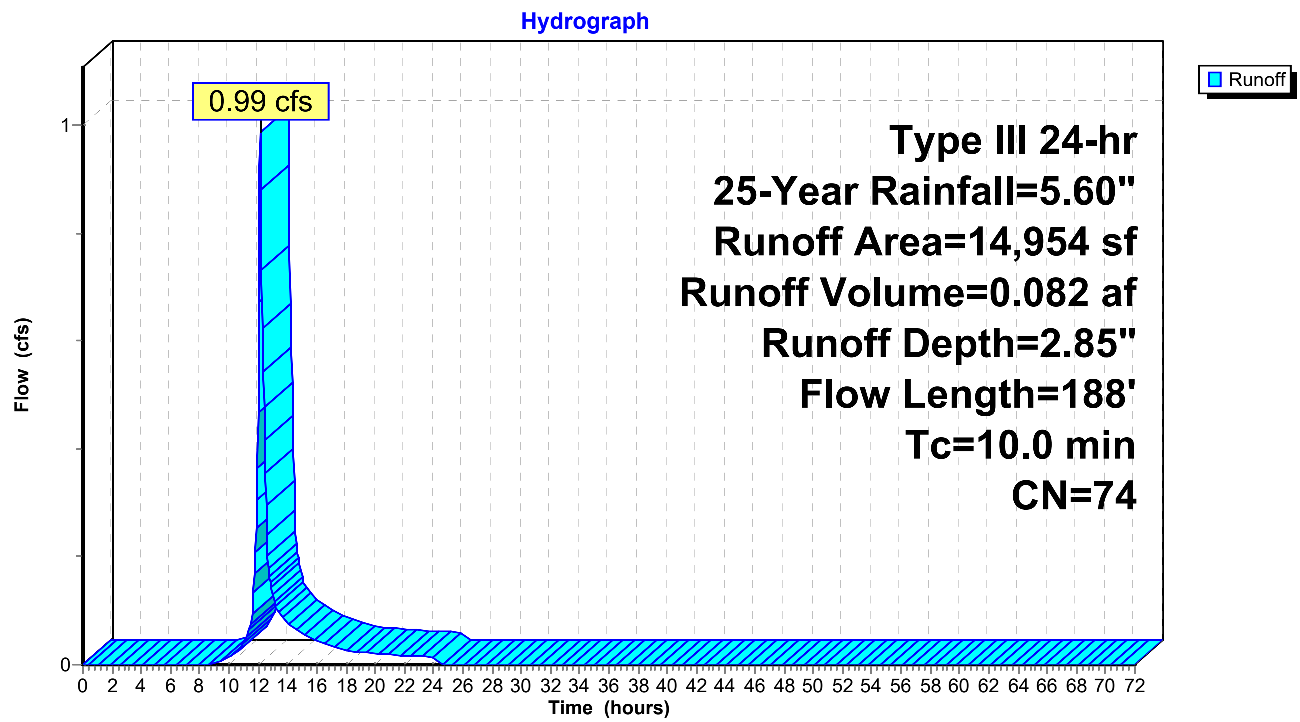
Runoff = 0.99 cfs @ 12.15 hrs, Volume= 0.082 af, Depth= 2.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
14,954	74	>75% Grass cover, Good, HSG C
14,954	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.40"
1.2	102	0.0400	1.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	36	0.3300	4.02		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.3	188	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 19S: POST (6)



Summary for Subcatchment 20S: POST (8)

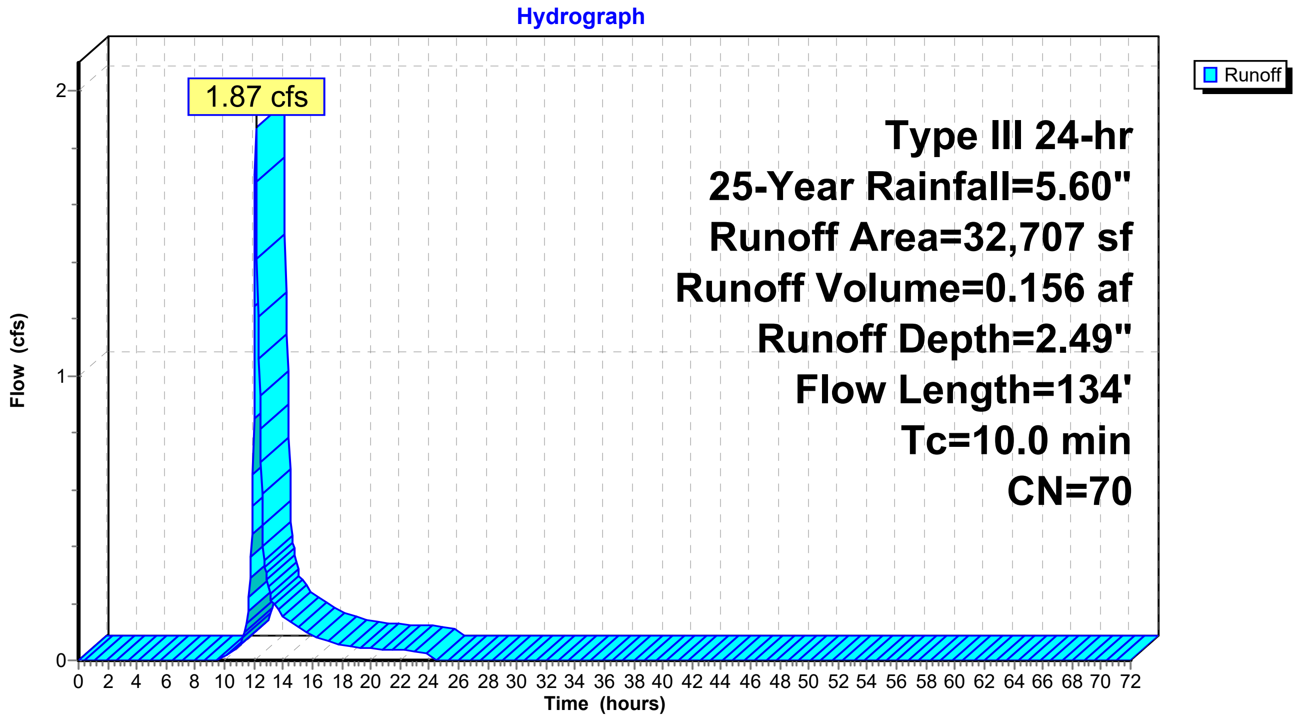
Runoff = 1.87 cfs @ 12.15 hrs, Volume= 0.156 af, Depth= 2.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
1,400	74	>75% Grass cover, Good, HSG C
31,307	70	Woods, Good, HSG C
32,707	70	Weighted Average
32,707	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0800	0.12		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
1.1	84	0.0700	1.32		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.0	134	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 20S: POST (8)



Summary for Subcatchment 26S: POST (4a)

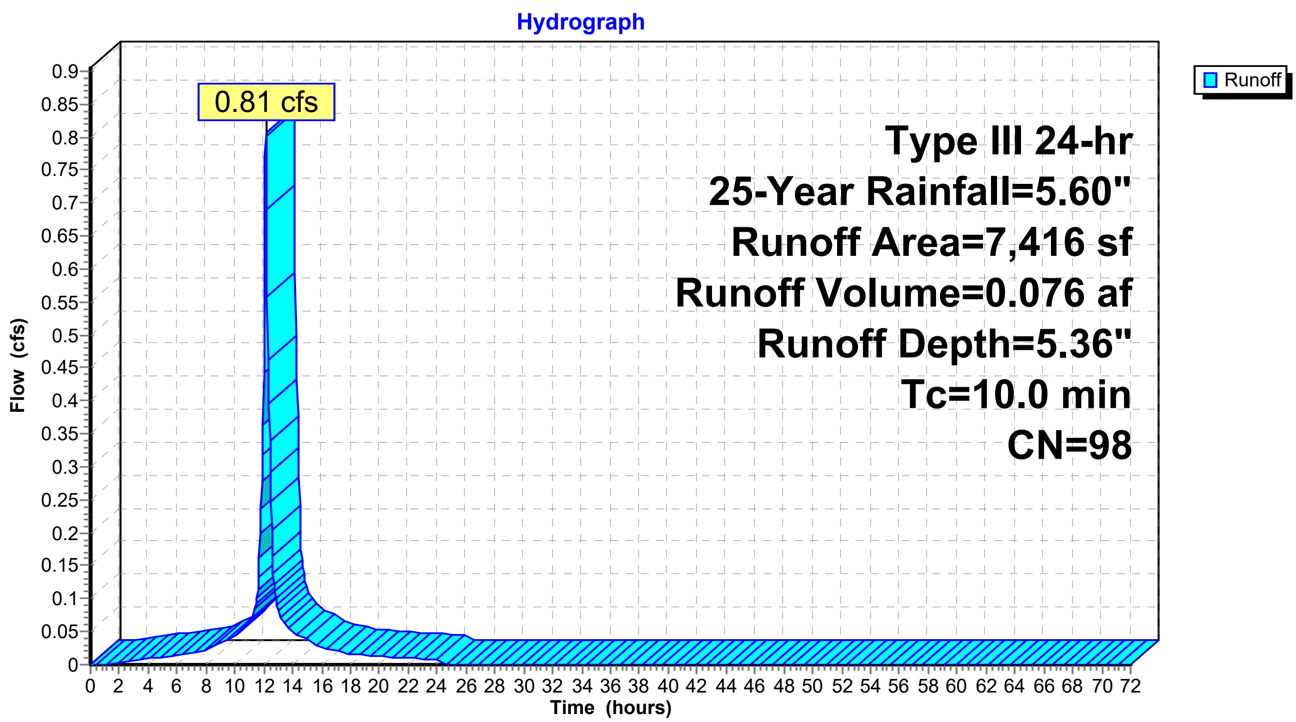
Runoff = 0.81 cfs @ 12.14 hrs, Volume= 0.076 af, Depth= 5.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
7,416	98	Paved parking, HSG C
7,416	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Tc 4A**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 26S: POST (4a)



Summary for Pond 17P: Basin #1

Inflow Area = 1.404 ac, 65.38% Impervious, Inflow Depth = 4.06" for 25-Year event
Inflow = 5.36 cfs @ 12.14 hrs, Volume= 0.475 af
Outflow = 3.49 cfs @ 12.27 hrs, Volume= 0.475 af, Atten= 35%, Lag= 8.1 min
Discarded = 0.16 cfs @ 12.27 hrs, Volume= 0.189 af
Secondary = 0.96 cfs @ 12.27 hrs, Volume= 0.025 af
Tertiary = 2.36 cfs @ 12.27 hrs, Volume= 0.260 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 80.33' @ 12.27 hrs Surf.Area= 2,817 sf Storage= 5,864 cf

Plug-Flow detention time= 131.0 min calculated for 0.474 af (100% of inflow)
Center-of-Mass det. time= 131.3 min (912.0 - 780.8)

Volume	Invert	Avail.Storage	Storage Description
#1	77.00'	11,397 cf	**Custom Stage Data (Conic)**Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
77.00	934	0	0	934
78.00	1,344	1,133	1,133	1,361
79.00	1,810	1,571	2,704	1,848
80.00	2,609	2,197	4,901	2,664
81.00	3,239	2,918	7,820	3,322
82.00	3,926	3,577	11,397	4,041

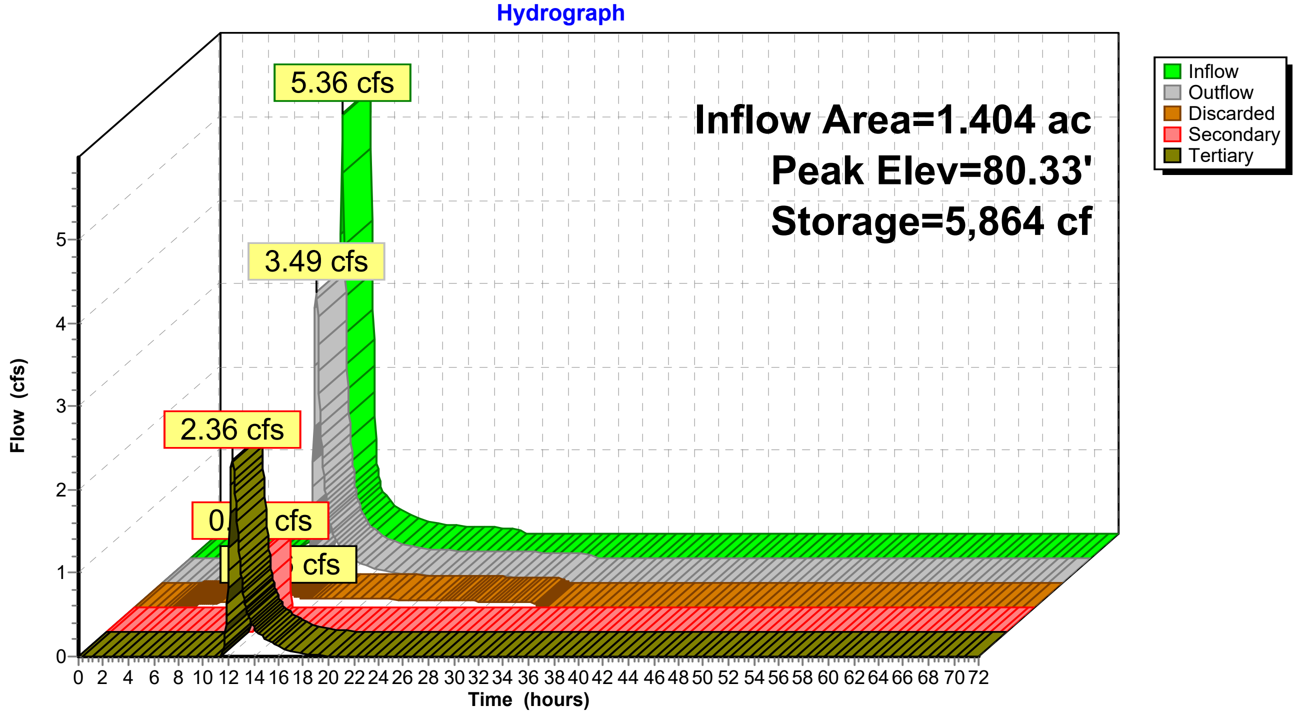
Device	Routing	Invert	Outlet Devices
#1	Discarded	77.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Secondary	80.00'	**8.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	78.75'	**0.5' long Sharp-Crested Rectangular Weir** 1 End Contraction(s) 3.0' Crest Height

Discarded OutFlow Max=0.16 cfs @ 12.27 hrs HW=80.32' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.16 cfs)

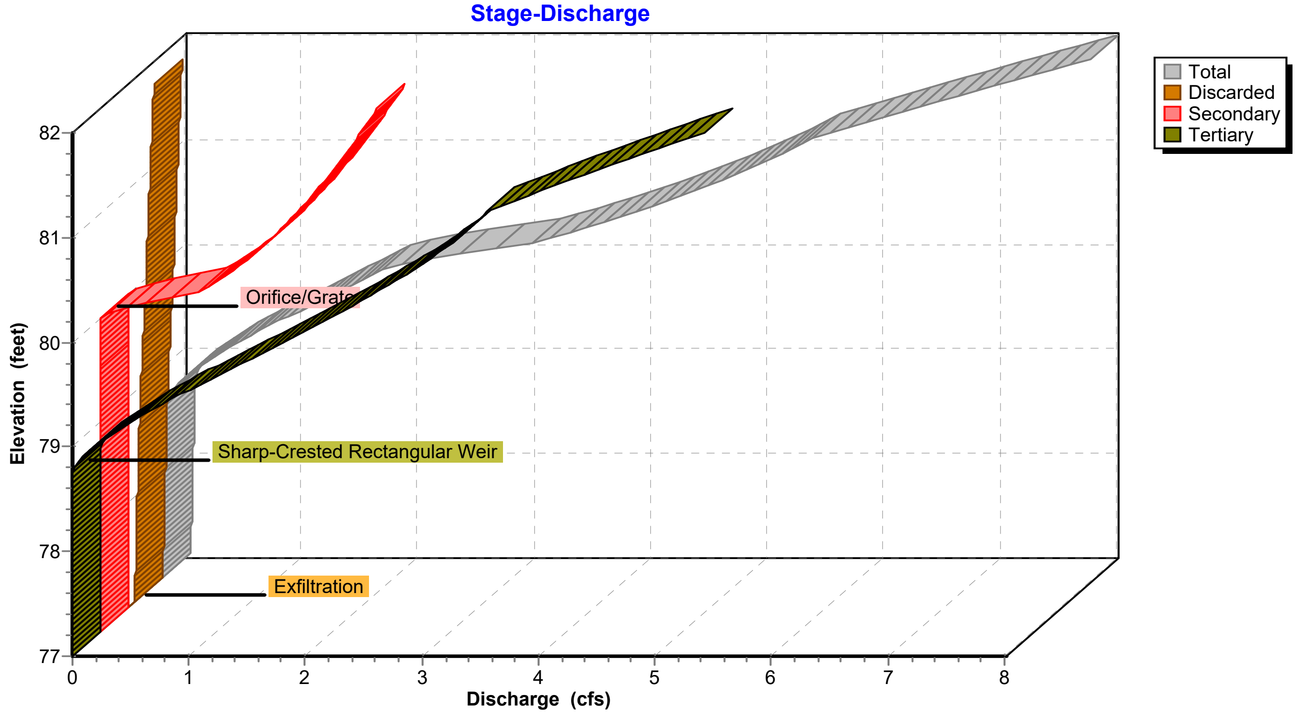
Secondary OutFlow Max=0.96 cfs @ 12.27 hrs HW=80.32' (Free Discharge)
└─**2=Orifice/Grate** (Orifice Controls 0.96 cfs @ 2.74 fps)

Tertiary OutFlow Max=2.35 cfs @ 12.27 hrs HW=80.32' (Free Discharge)
└─**3=Sharp-Crested Rectangular Weir** (Weir Controls 2.35 cfs @ 4.37 fps)

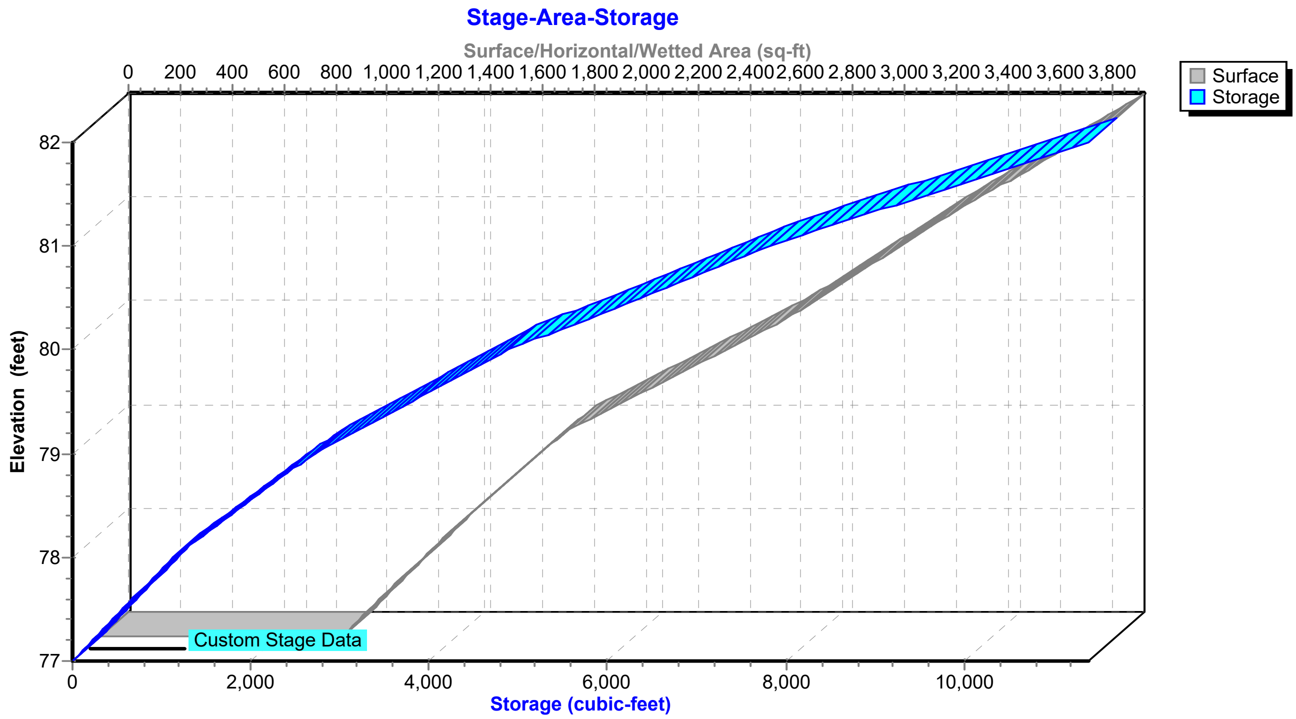
Pond 17P: Basin #1



Pond 17P: Basin #1



Pond 17P: Basin #1



Summary for Pond 21P: Basin #2

Inflow Area = 0.178 ac, 57.09% Impervious, Inflow Depth = 4.24" for 25-Year event
Inflow = 0.74 cfs @ 12.14 hrs, Volume= 0.063 af
Outflow = 0.72 cfs @ 12.17 hrs, Volume= 0.063 af, Atten= 3%, Lag= 1.8 min
Discarded = 0.02 cfs @ 12.17 hrs, Volume= 0.025 af
Secondary = 0.70 cfs @ 12.17 hrs, Volume= 0.038 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 74.74' @ 12.17 hrs Surf.Area= 788 sf Storage= 411 cf

Plug-Flow detention time= 104.3 min calculated for 0.063 af (100% of inflow)
Center-of-Mass det. time= 104.5 min (902.1 - 797.6)

Volume	Invert	Avail.Storage	Storage Description
#1	74.00'	612 cf	**Custom Stage Data (Conic)**Listed below

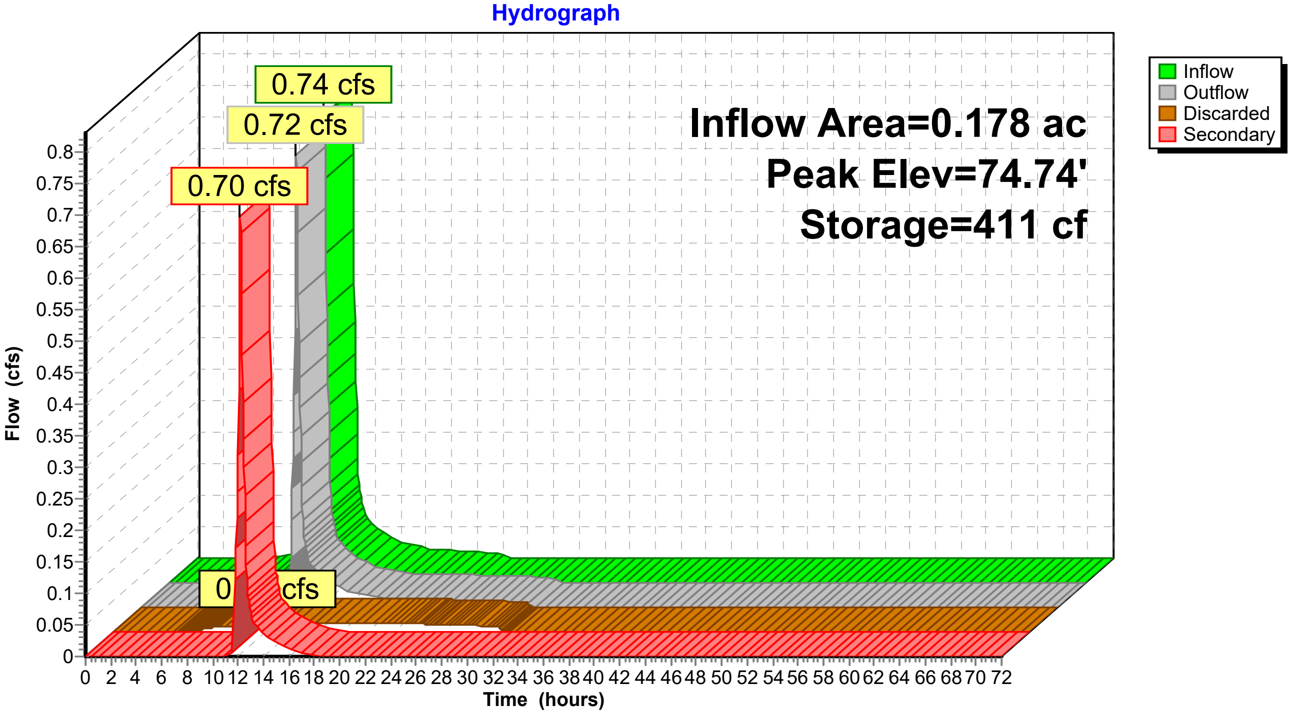
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
74.00	379	0	0	379
74.50	513	222	222	518
75.00	1,081	390	612	1,088

Device	Routing	Invert	Outlet Devices
#1	Discarded	74.00'	**1.020 in/hr Exfiltration over Wetted area**
#2	Secondary	74.60'	**4.0' long x 1.00' rise Sharp-Crested Rectangular Weir** 1 End Contraction(s)

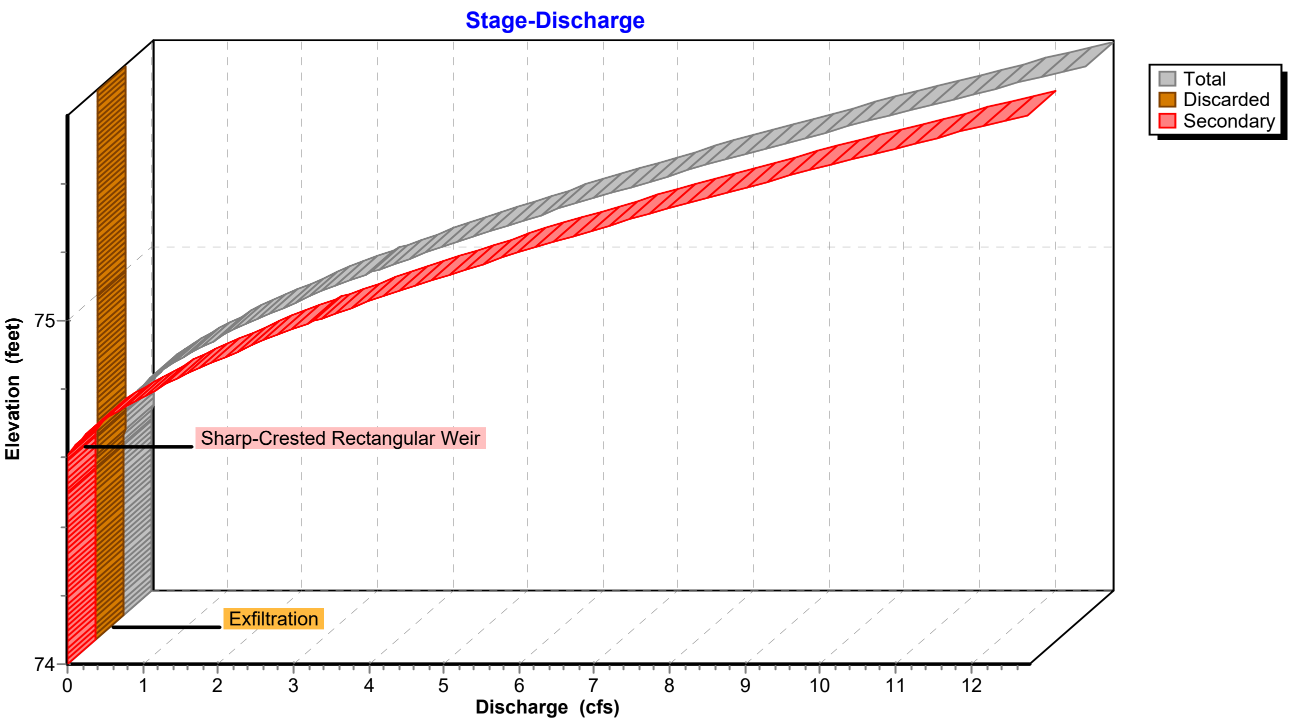
Discarded OutFlow Max=0.02 cfs @ 12.17 hrs HW=74.74' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Secondary OutFlow Max=0.68 cfs @ 12.17 hrs HW=74.74' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.68 cfs @ 1.22 fps)

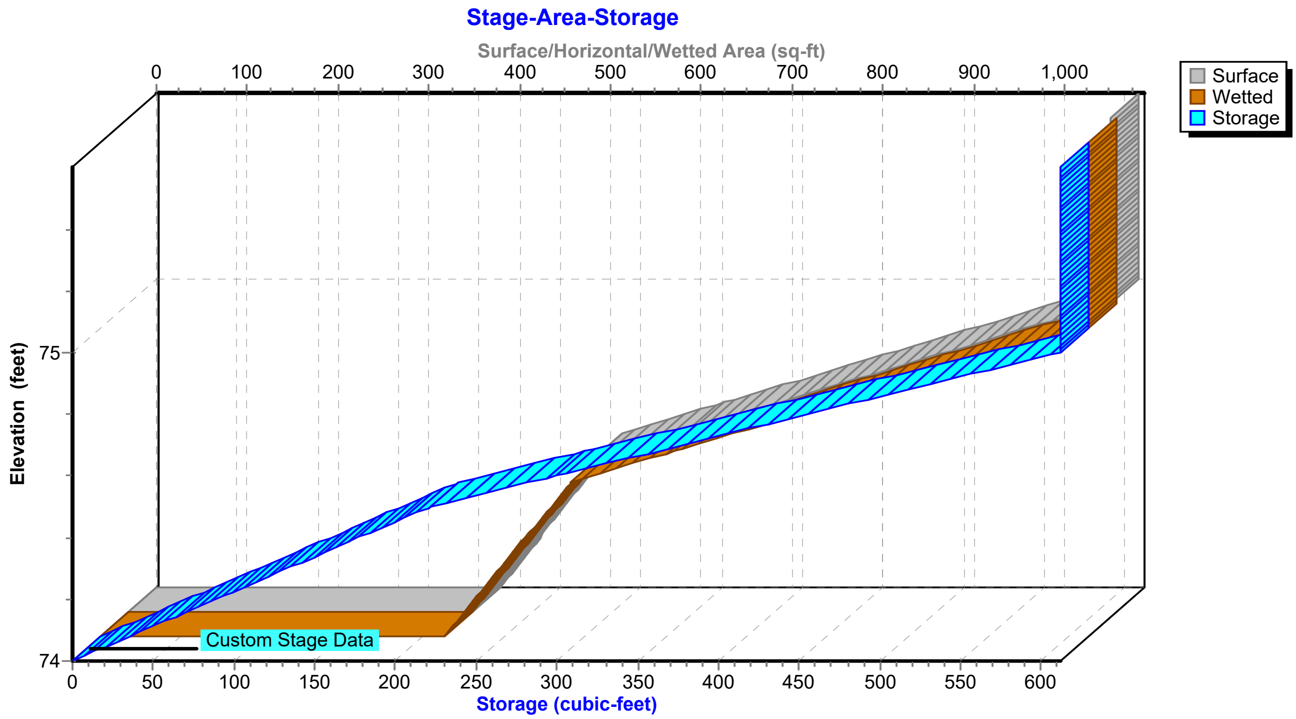
Pond 21P: Basin #2



Pond 21P: Basin #2



Pond 21P: Basin #2



Summary for Pond 25P: Subsurface infiltration

Inflow Area = 0.115 ac,100.00% Impervious, Inflow Depth = 5.36" for 25-Year event
Inflow = 0.54 cfs @ 12.14 hrs, Volume= 0.051 af
Outflow = 0.04 cfs @ 13.45 hrs, Volume= 0.051 af, Atten= 92%, Lag= 78.7 min
Discarded = 0.04 cfs @ 13.45 hrs, Volume= 0.051 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 83.44' @ 13.45 hrs Surf.Area= 0.008 ac Storage= 0.023 af

Plug-Flow detention time= 227.9 min calculated for 0.051 af (100% of inflow)
Center-of-Mass det. time= 227.9 min (977.8 - 749.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	79.00'	0.010 af	**10.80'W x 34.00'L x 5.50'H Field A** 0.046 af Overall - 0.022 af Embedded = 0.025 af x 40.0% Voids
#2A	80.00'	0.016 af	**Concrete Galley 4x4x4** x 16 Inside #1 Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf 2 Rows of 8 Chambers
		0.026 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	79.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	84.00'	**4.0" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=0.04 cfs @ 13.45 hrs HW=83.44' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=79.00' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Pond 25P: Subsurface infiltration - Chamber Wizard Field A

Chamber Model = Concrete Galley 4x4x4 (Concrete Galley, UCPI 4x4x4 Galley or equivalent)
Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf
Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf

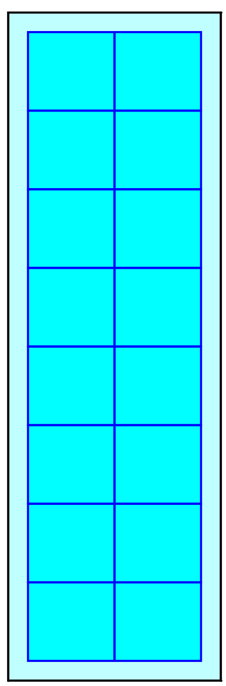
8 Chambers/Row x 4.00' Long = 32.00' Row Length +12.0" End Stone x 2 = 34.00' Base Length
2 Rows x 52.8" Wide + 12.0" Side Stone x 2 = 10.80' Base Width
12.0" Base + 48.0" Chamber Height + 6.0" Cover = 5.50' Field Height

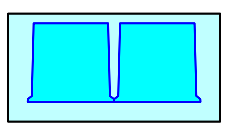
16 Chambers x 44.3 cf = 709.5 cf Chamber Storage
16 Chambers x 58.9 cf = 942.0 cf Displacement

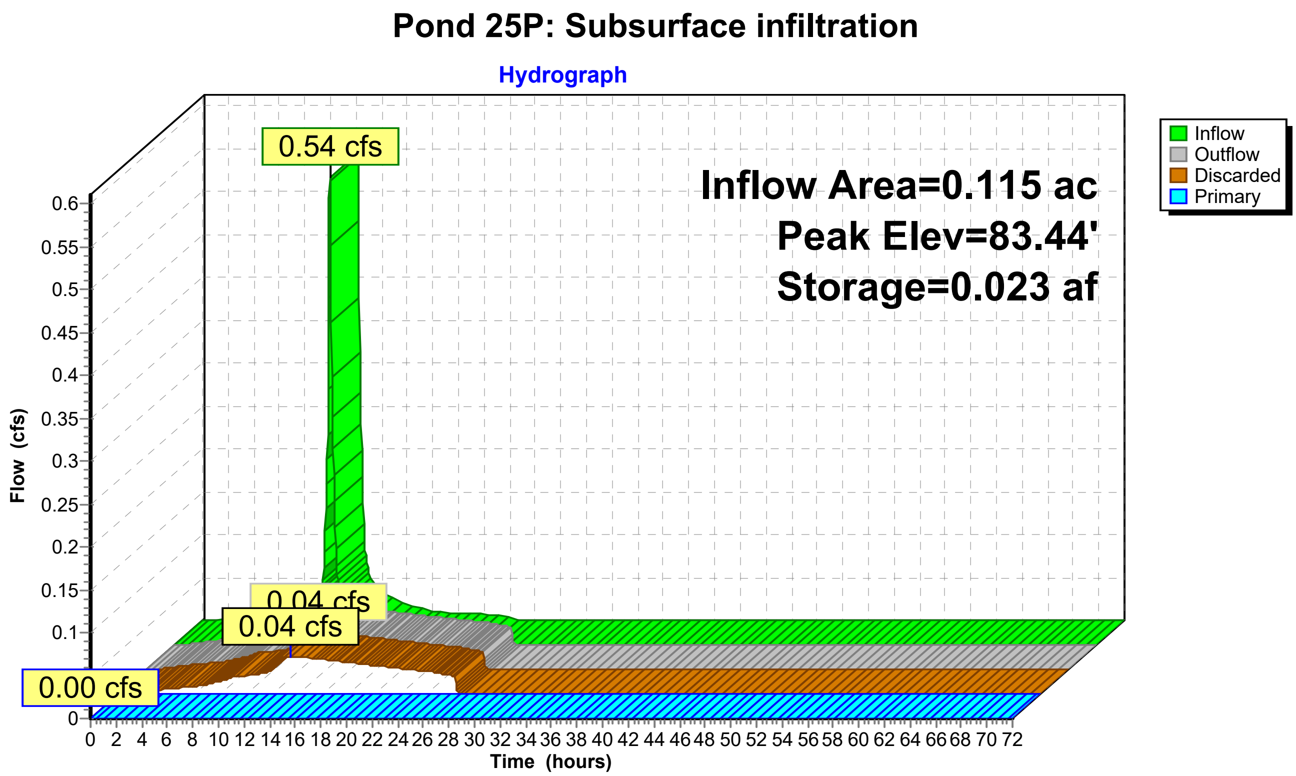
2,019.6 cf Field - 942.0 cf Chambers = 1,077.6 cf Stone x 40.0% Voids = 431.0 cf Stone Storage

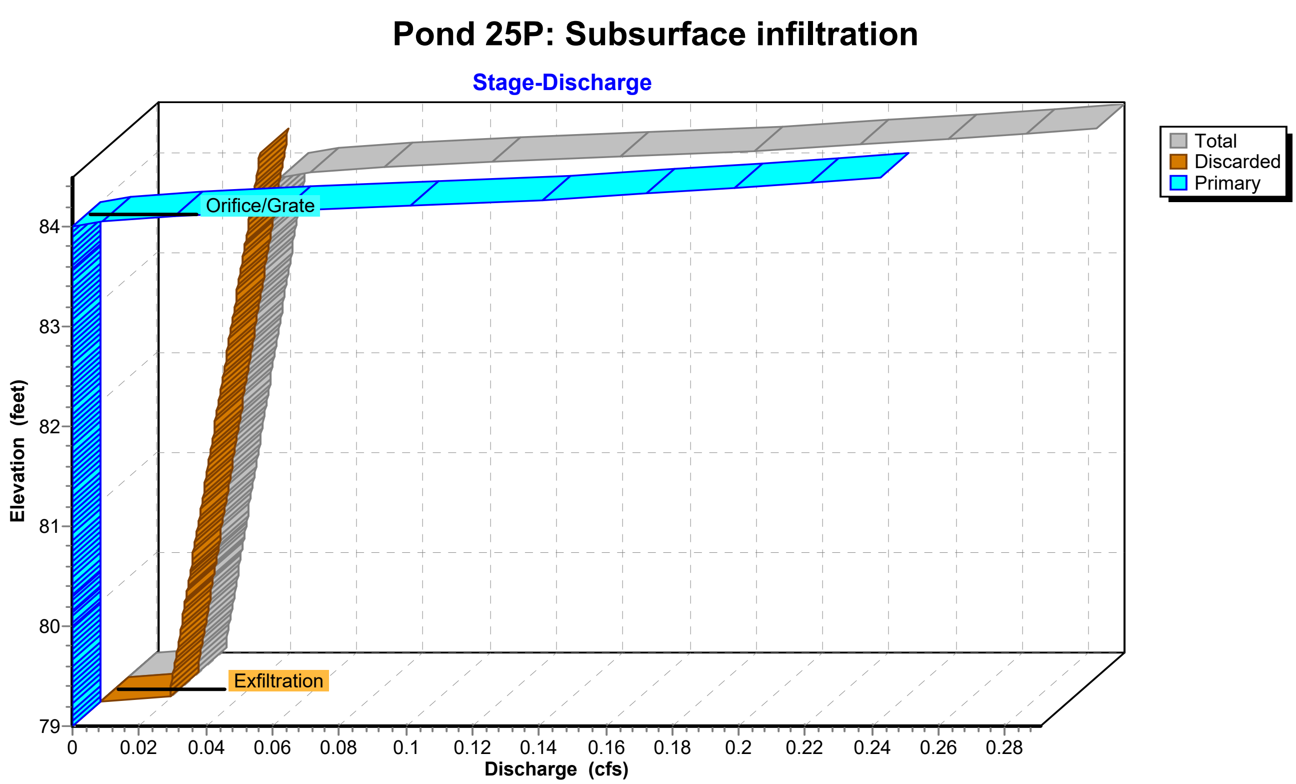
Chamber Storage + Stone Storage = 1,140.5 cf = 0.026 af
Overall Storage Efficiency = 56.5%
Overall System Size = 34.00' x 10.80' x 5.50'

16 Chambers @ $ 300.00 /ea = $ 4,800.00
74.8 cy Field Excavation @ $ 10.00 /cy = $ 748.00
39.9 cy Stone @ $ 30.00 /cy = $ 1,197.31
Total Cost = $ 6,745.31

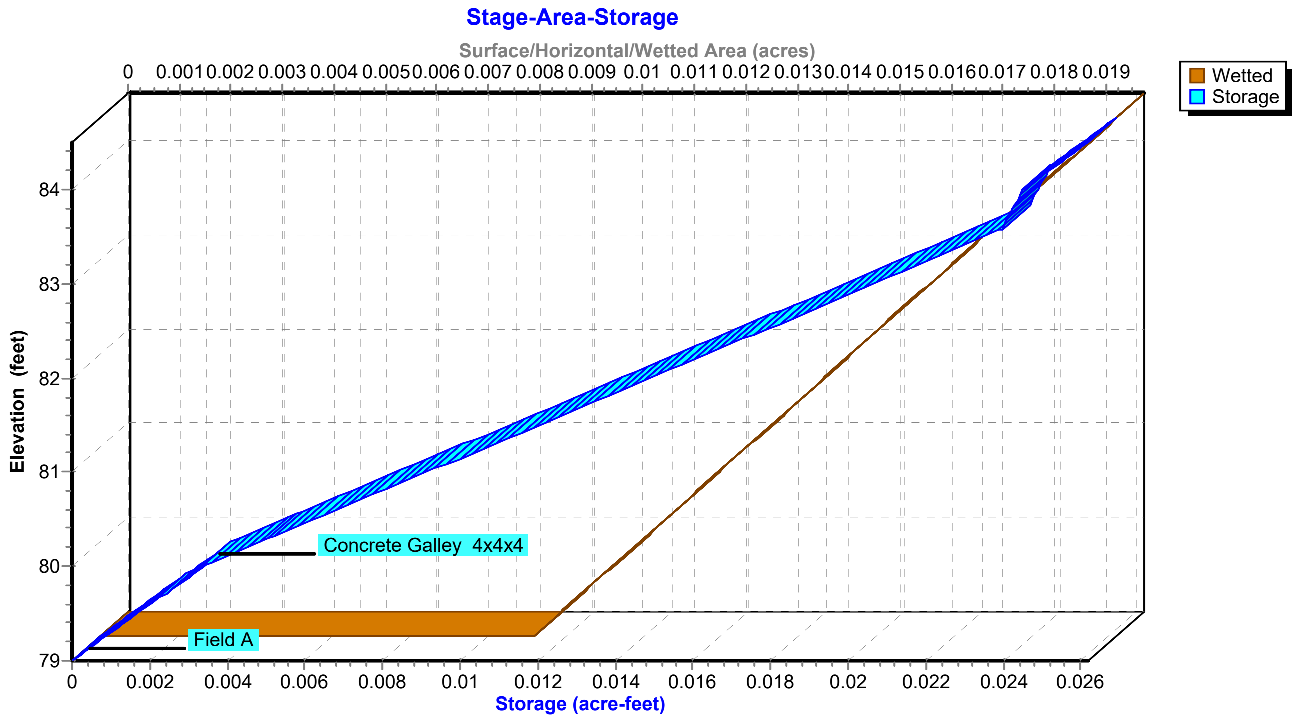





Pond 25P: Subsurface infiltration
Hydrograph
0.54 cfs
0.04 cfs
0.04 cfs
0.00 cfs
Inflow Area=0.115 ac
Peak Elev=83.44'
Storage=0.023 af
Inflow
Outflow
Discarded
Primary
Flow (cfs)
0 0.1 0.15 0.2 0.25 0.3 0.35 0.4 0.45 0.5 0.55 0.6
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72
Time (hours)


Pond 25P: Subsurface infiltration
Stage-Discharge
Total
Discarded
Primary
Orifice/Grate
Exfiltration
Elevation (feet)
79 80 81 82 83 84
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
Discharge (cfs)

Pond 25P: Subsurface infiltration

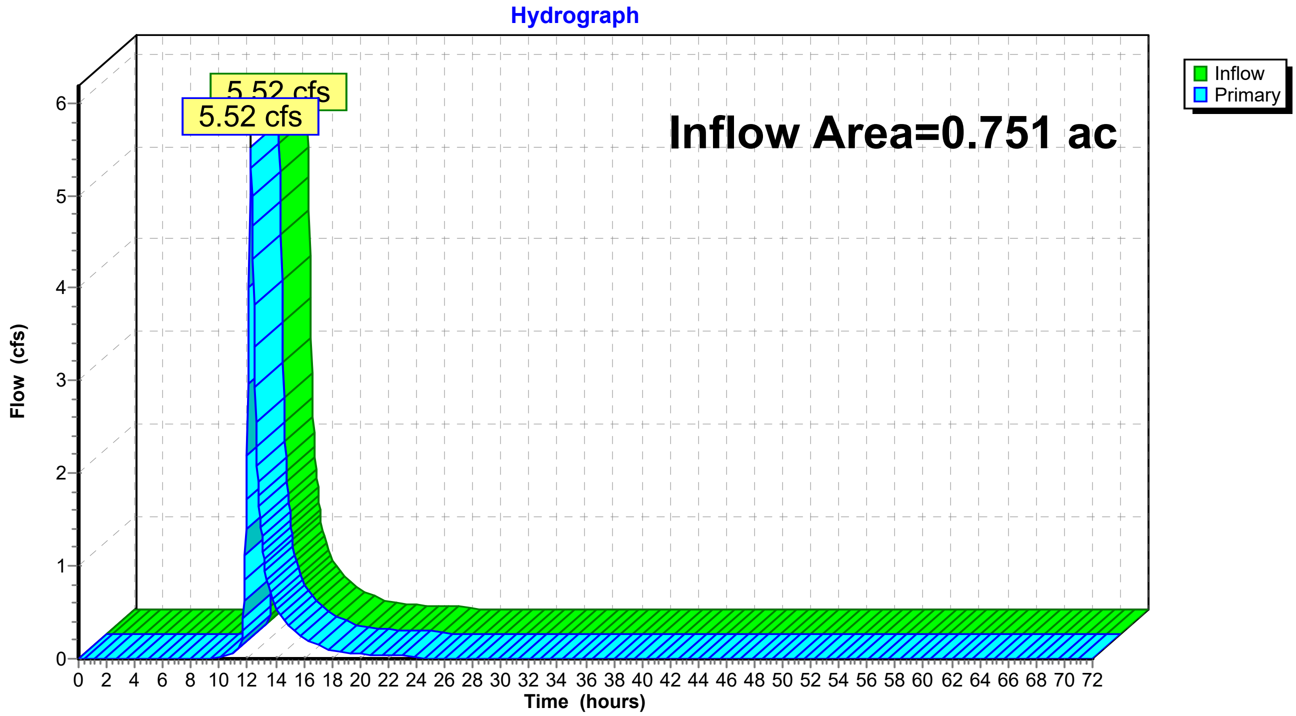


Summary for Link 23L: (Combined Link)

Inflow Area = 0.751 ac, 0.00% Impervious, Inflow Depth = 7.66" for 25-Year event
Inflow = 5.52 cfs @ 12.21 hrs, Volume= 0.479 af
Primary = 5.52 cfs @ 12.21 hrs, Volume= 0.479 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Link 23L: (Combined Link)



Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 13S: POST (4) Runoff Area=33,810 sf 81.58% Impervious Runoff Depth=6.29"
Flow Length=298' Tc=10.0 min CN=94 Runoff=4.51 cfs 0.407 af

Subcatchment 15S: PRE (3) Runoff Area=97,629 sf 0.00% Impervious Runoff Depth=3.62"
Flow Length=382' Tc=10.0 min CN=70 Runoff=8.20 cfs 0.676 af

Subcatchment 16S: POST (7) Runoff Area=7,754 sf 57.09% Impervious Runoff Depth=5.59"
Flow Length=156' Slope=0.0500 '/' Tc=10.0 min CN=88 Runoff=0.97 cfs 0.083 af

Subcatchment 18S: POST (5) Runoff Area=5,000 sf 100.00% Impervious Runoff Depth=6.76"
Tc=10.0 min CN=98 Runoff=0.68 cfs 0.065 af

Subcatchment 19S: POST (6) Runoff Area=14,954 sf 0.00% Impervious Runoff Depth=4.04"
Flow Length=188' Tc=10.0 min CN=74 Runoff=1.40 cfs 0.116 af

Subcatchment 20S: POST (8) Runoff Area=32,707 sf 0.00% Impervious Runoff Depth=3.62"
Flow Length=134' Tc=10.0 min CN=70 Runoff=2.75 cfs 0.226 af

Subcatchment 26S: POST (4a) Runoff Area=7,416 sf 100.00% Impervious Runoff Depth=6.76"
Tc=10.0 min CN=98 Runoff=1.01 cfs 0.096 af

Pond 17P: Basin #1 Peak Elev=80.66' Storage=6,841 cf Inflow=6.92 cfs 0.625 af
Discarded=0.17 cfs 0.205 af Secondary=1.37 cfs 0.055 af Tertiary=2.88 cfs 0.366 af Outflow=4.42 cfs 0.625 af

Pond 21P: Basin #2 Peak Elev=74.77' Storage=433 cf Inflow=0.97 cfs 0.083 af
Discarded=0.02 cfs 0.027 af Secondary=0.92 cfs 0.056 af Outflow=0.94 cfs 0.083 af

Pond 25P: Subsurface infiltration Peak Elev=84.39' Storage=0.026 af Inflow=0.68 cfs 0.065 af
Discarded=0.05 cfs 0.058 af Primary=0.20 cfs 0.007 af Outflow=0.24 cfs 0.065 af

Link 23L: (Combined Link) Inflow=7.42 cfs 0.702 af
Primary=7.42 cfs 0.702 af

Total Runoff Area = 4.575 ac Runoff Volume = 1.668 af Average Runoff Depth = 4.38"
77.71% Pervious = 3.555 ac 22.29% Impervious = 1.020 ac

Summary for Subcatchment 13S: POST (4)

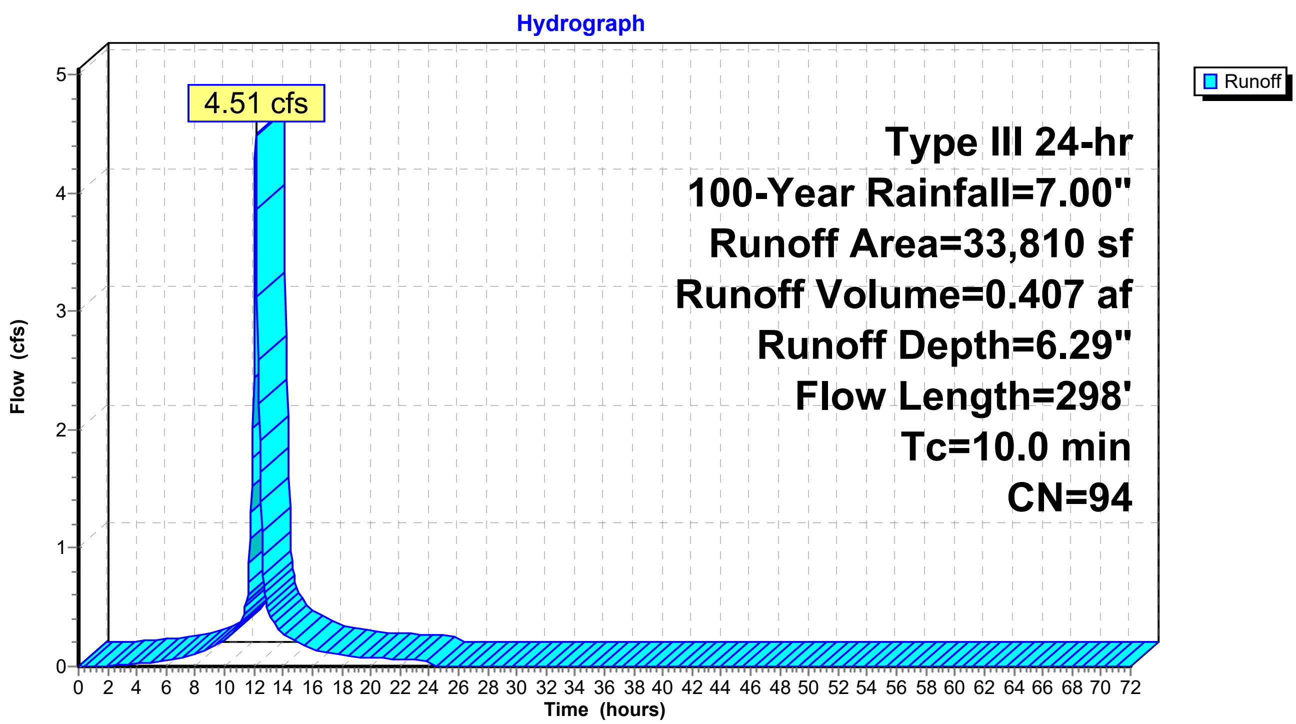
Runoff = 4.51 cfs @ 12.14 hrs, Volume= 0.407 af, Depth= 6.29"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
27,582	98	Paved parking, HSG C
1,469	70	Woods, Good, HSG C
4,759	79	50-75% Grass cover, Fair, HSG C
33,810	94	Weighted Average
6,228	77	18.42% Pervious Area
27,582	98	81.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	40	0.0500	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
0.1	10	0.0500	1.29		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
1.1	248	0.0370	3.90		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
8.1	298	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 13S: POST (4)



Summary for Subcatchment 15S: PRE (3)

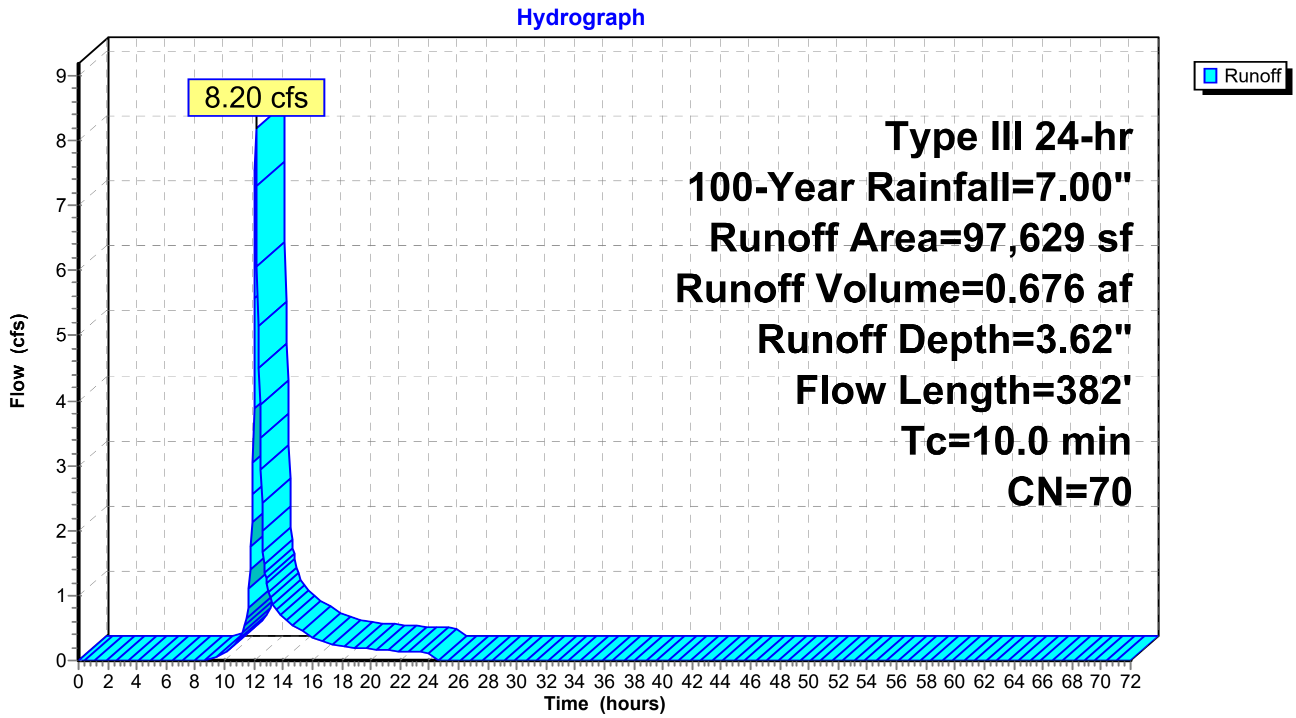
Runoff = 8.20 cfs @ 12.15 hrs, Volume= 0.676 af, Depth= 3.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
97,629	70	Woods, Good, HSG C
97,629	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.8	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
2.6	138	0.0320	0.89		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	146	0.0710	1.33		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.5	48	0.0850	1.46		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.7	382	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 15S: PRE (3)



Summary for Subcatchment 16S: POST (7)

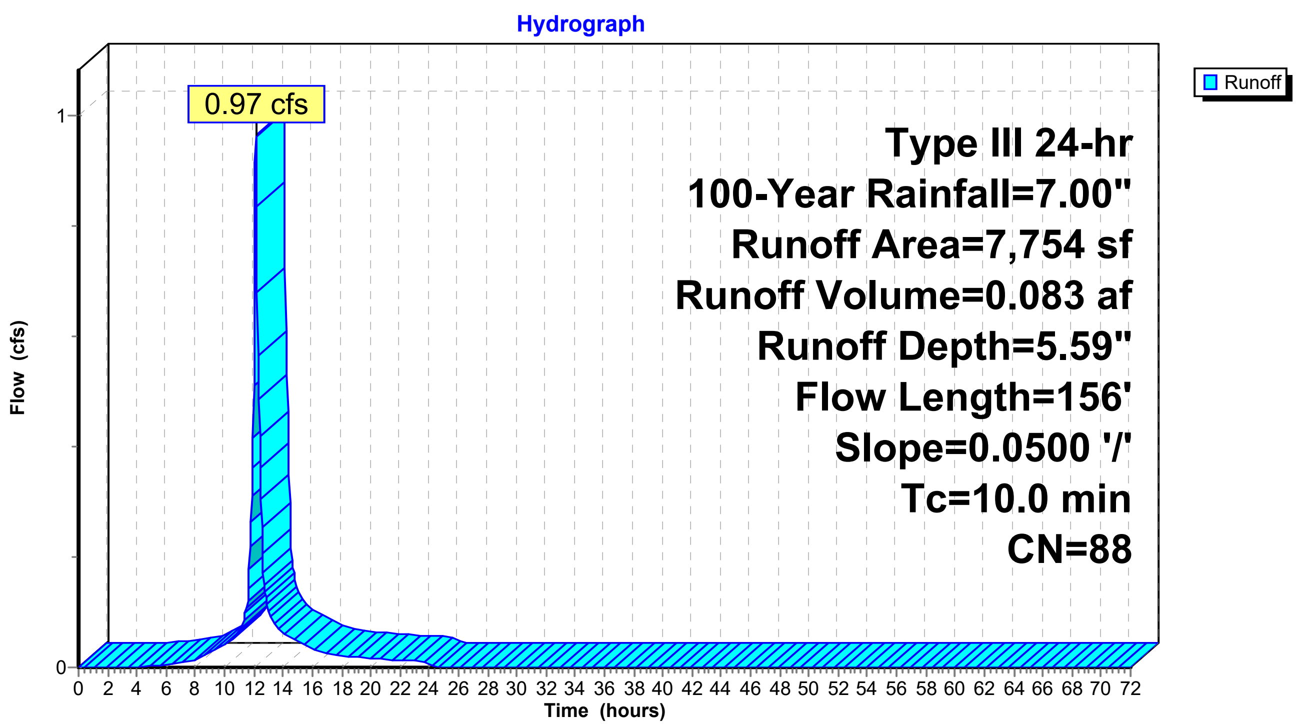
Runoff = 0.97 cfs @ 12.14 hrs, Volume= 0.083 af, Depth= 5.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
3,327	74	>75% Grass cover, Good, HSG C
4,427	98	Paved parking, HSG C
7,754	88	Weighted Average
3,327	74	42.91% Pervious Area
4,427	98	57.09% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.5	50	0.0500	1.78		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.40"
0.4	106	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.9	156	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 16S: POST (7)



Summary for Subcatchment 18S: POST (5)

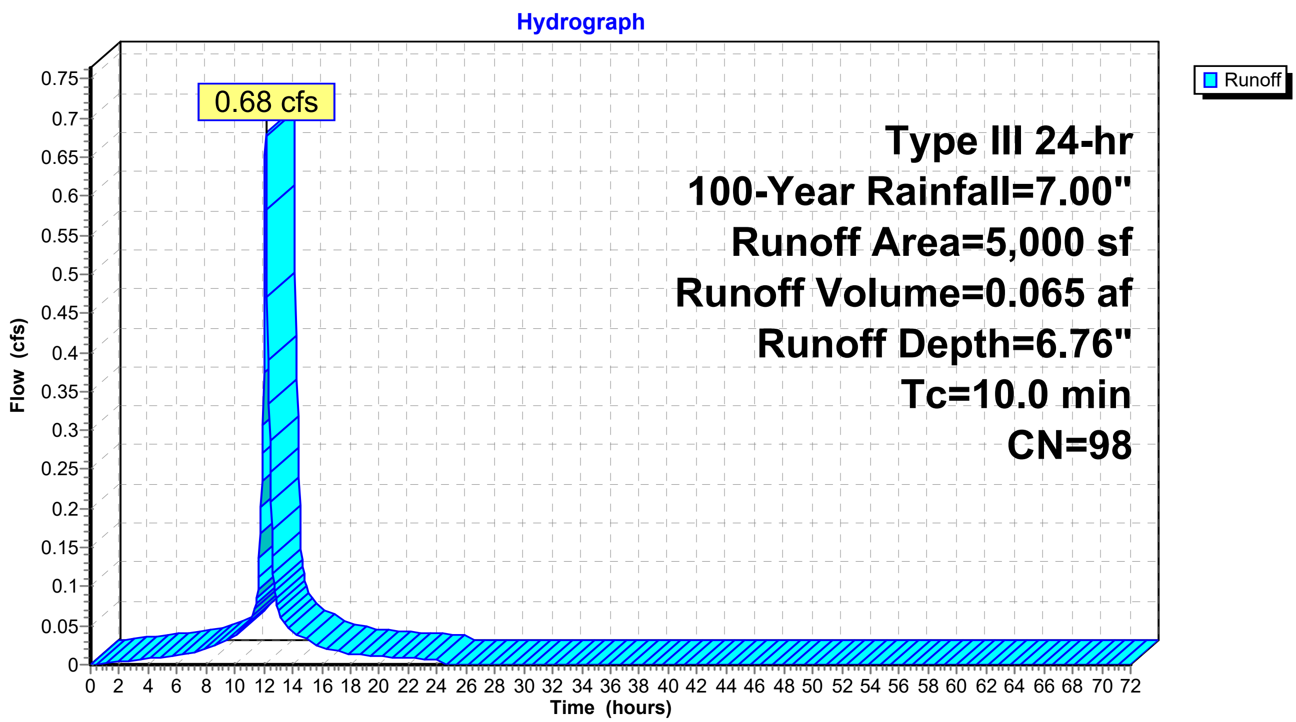
Runoff = 0.68 cfs @ 12.14 hrs, Volume= 0.065 af, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,000	98	Roofs, HSG C
5,000	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Estimate**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 18S: POST (5)



Summary for Subcatchment 19S: POST (6)

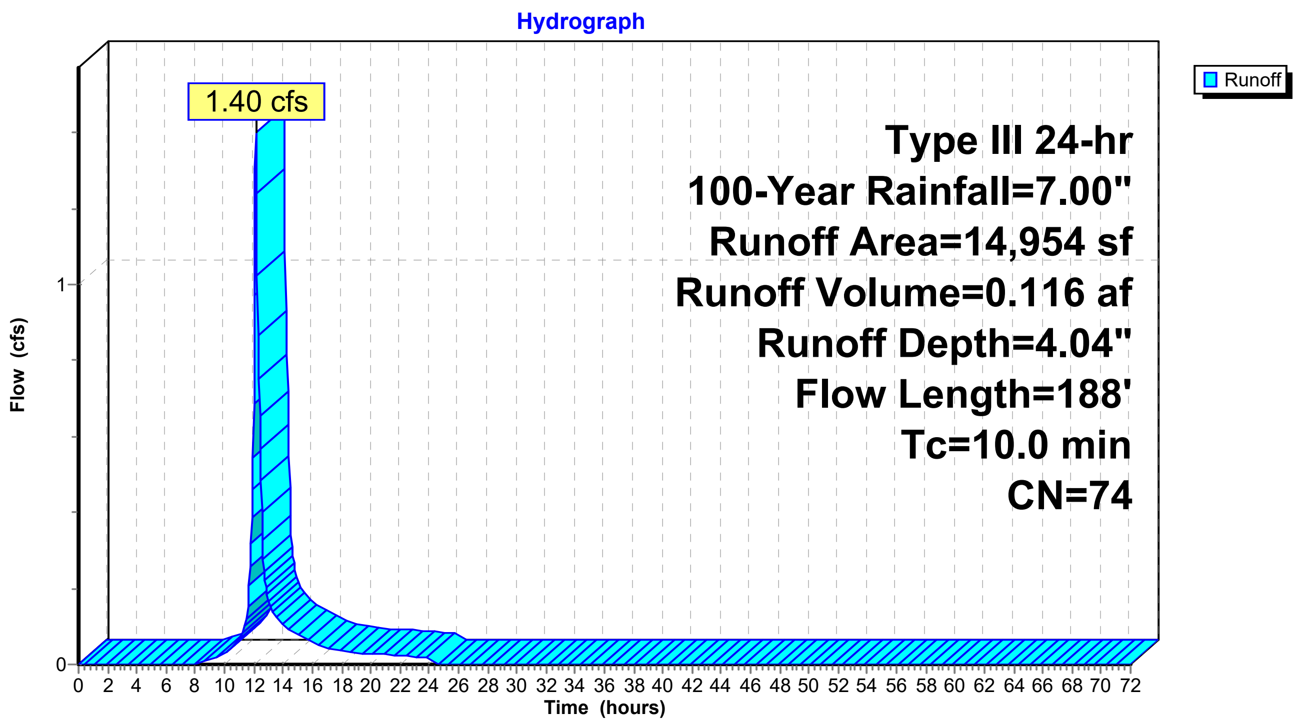
Runoff = 1.40 cfs @ 12.14 hrs, Volume= 0.116 af, Depth= 4.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
14,954	74	>75% Grass cover, Good, HSG C
14,954	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.40"
1.2	102	0.0400	1.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.1	36	0.3300	4.02		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.3	188	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 19S: POST (6)



Summary for Subcatchment 20S: POST (8)

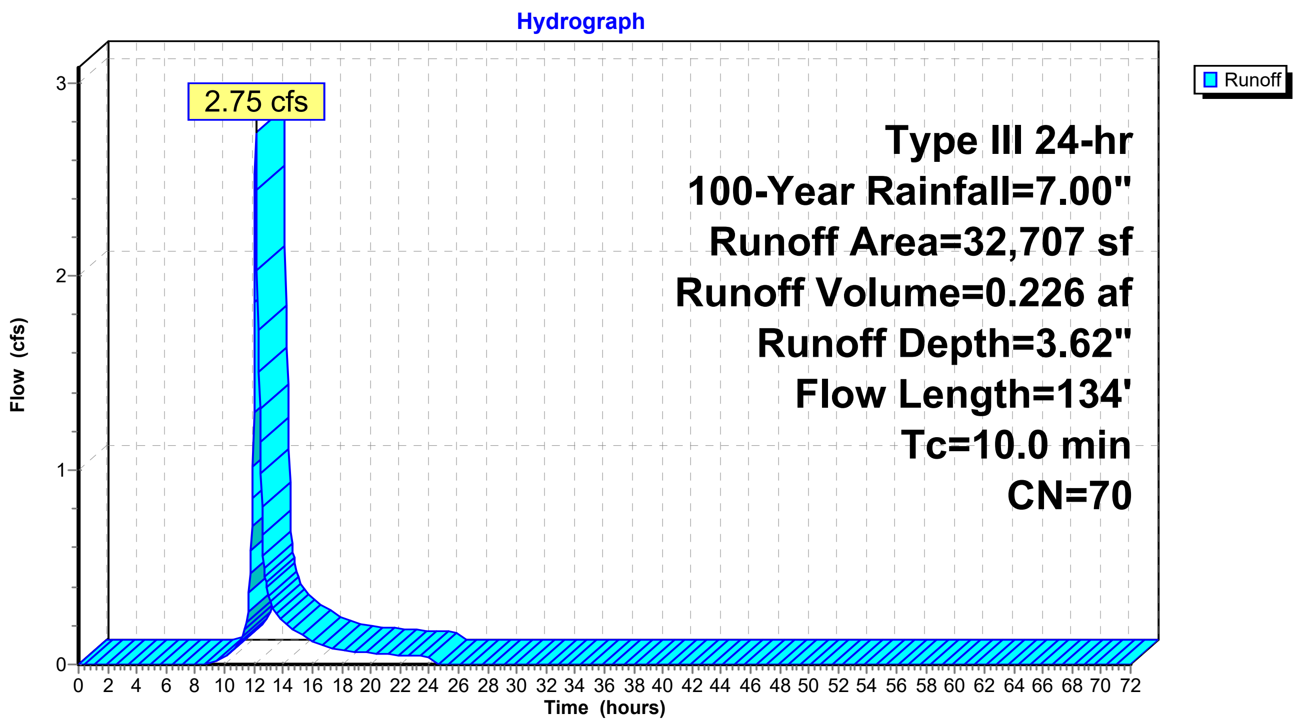
Runoff = 2.75 cfs @ 12.15 hrs, Volume= 0.226 af, Depth= 3.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
1,400	74	>75% Grass cover, Good, HSG C
31,307	70	Woods, Good, HSG C
32,707	70	Weighted Average
32,707	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.0800	0.12		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.40"
1.1	84	0.0700	1.32		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.0	134	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 20S: POST (8)



Summary for Subcatchment 26S: POST (4a)

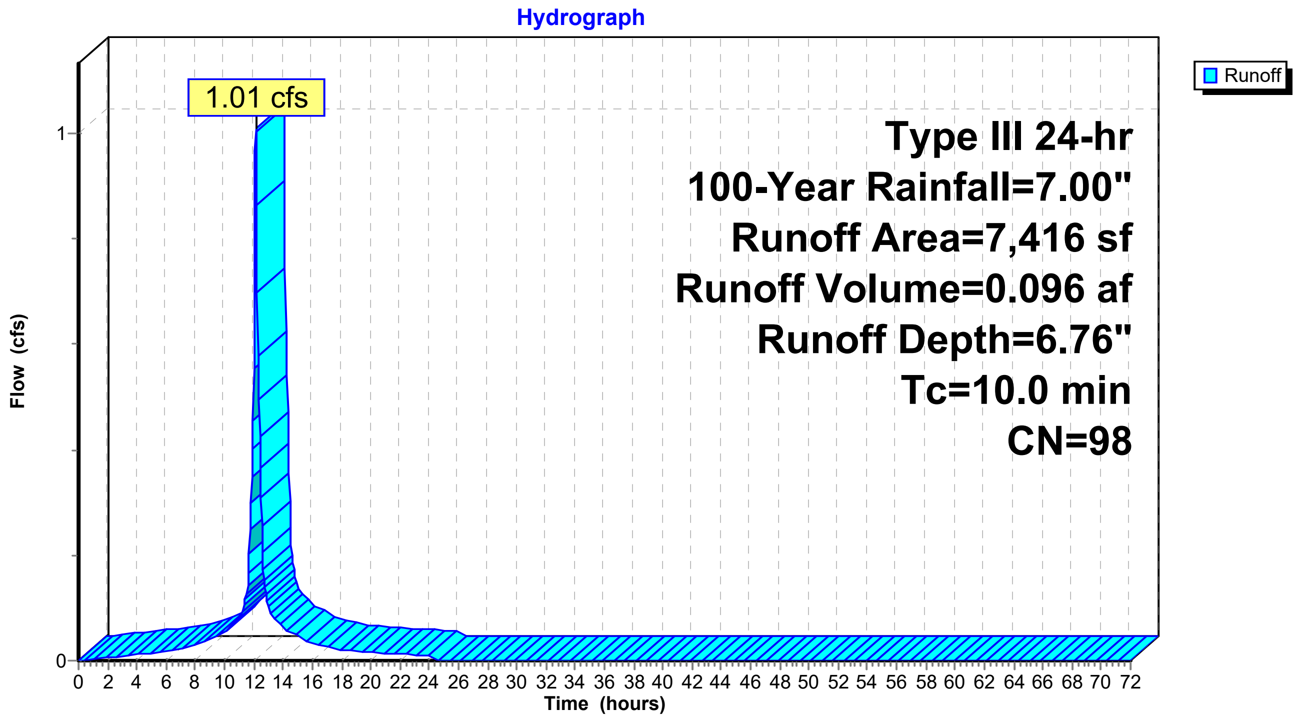
Runoff = 1.01 cfs @ 12.14 hrs, Volume= 0.096 af, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
7,416	98	Paved parking, HSG C
7,416	98	100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Tc 4A**
5.0	0	Total, Increased to minimum Tc = 10.0 min			

Subcatchment 26S: POST (4a)



Summary for Pond 17P: Basin #1

Inflow Area = 1.404 ac, 65.38% Impervious, Inflow Depth = 5.34" for 100-Year event
Inflow = 6.92 cfs @ 12.14 hrs, Volume= 0.625 af
Outflow = 4.42 cfs @ 12.28 hrs, Volume= 0.625 af, Atten= 36%, Lag= 8.4 min
Discarded = 0.17 cfs @ 12.28 hrs, Volume= 0.205 af
Secondary = 1.37 cfs @ 12.28 hrs, Volume= 0.055 af
Tertiary = 2.88 cfs @ 12.28 hrs, Volume= 0.366 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 80.66' @ 12.28 hrs Surf.Area= 3,028 sf Storage= 6,841 cf

Plug-Flow detention time= 112.1 min calculated for 0.624 af (100% of inflow)
Center-of-Mass det. time= 112.4 min (887.9 - 775.5)

Volume	Invert	Avail.Storage	Storage Description
#1	77.00'	11,397 cf	**Custom Stage Data (Conic)** Listed below

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
77.00	934	0	0	934
78.00	1,344	1,133	1,133	1,361
79.00	1,810	1,571	2,704	1,848
80.00	2,609	2,197	4,901	2,664
81.00	3,239	2,918	7,820	3,322
82.00	3,926	3,577	11,397	4,041

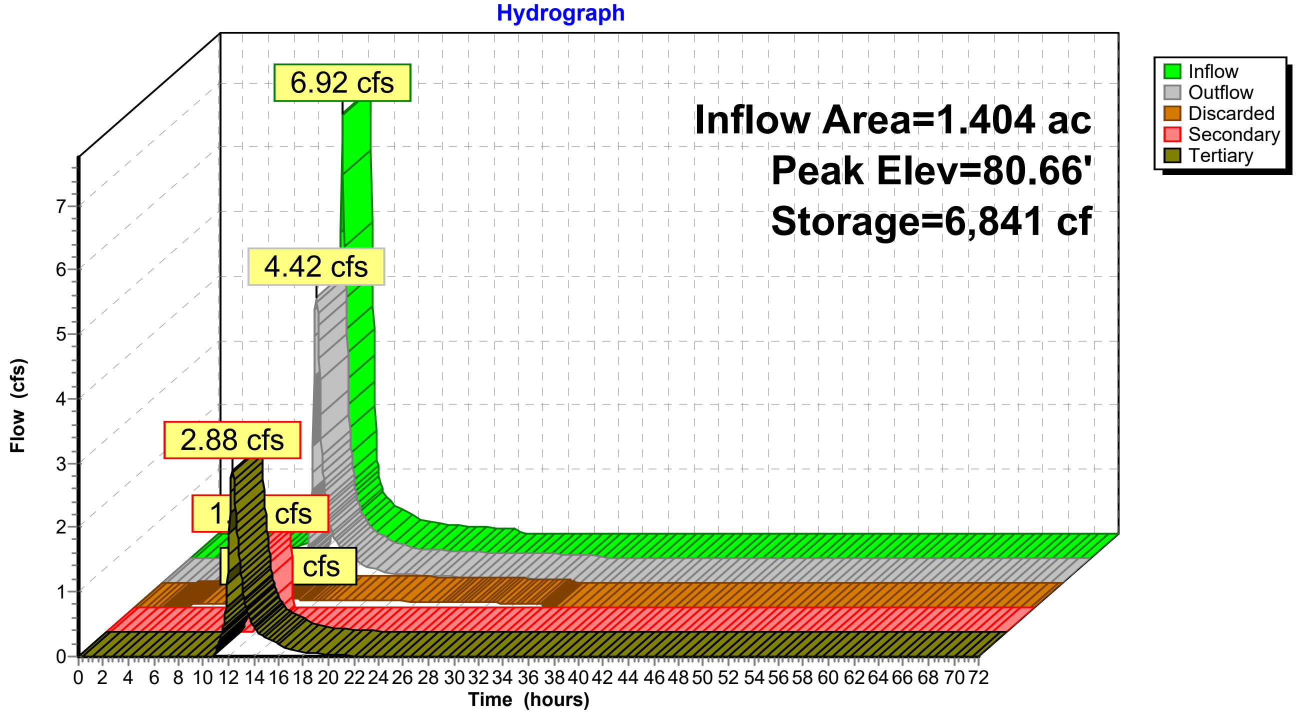
Device	Routing	Invert	Outlet Devices
#1	Discarded	77.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Secondary	80.00'	**8.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Tertiary	78.75'	**0.5' long Sharp-Crested Rectangular Weir** 1 End Contraction(s) 3.0' Crest Height

Discarded OutFlow Max=0.17 cfs @ 12.28 hrs HW=80.66' (Free Discharge)
└—**1=Exfiltration** (Exfiltration Controls 0.17 cfs)

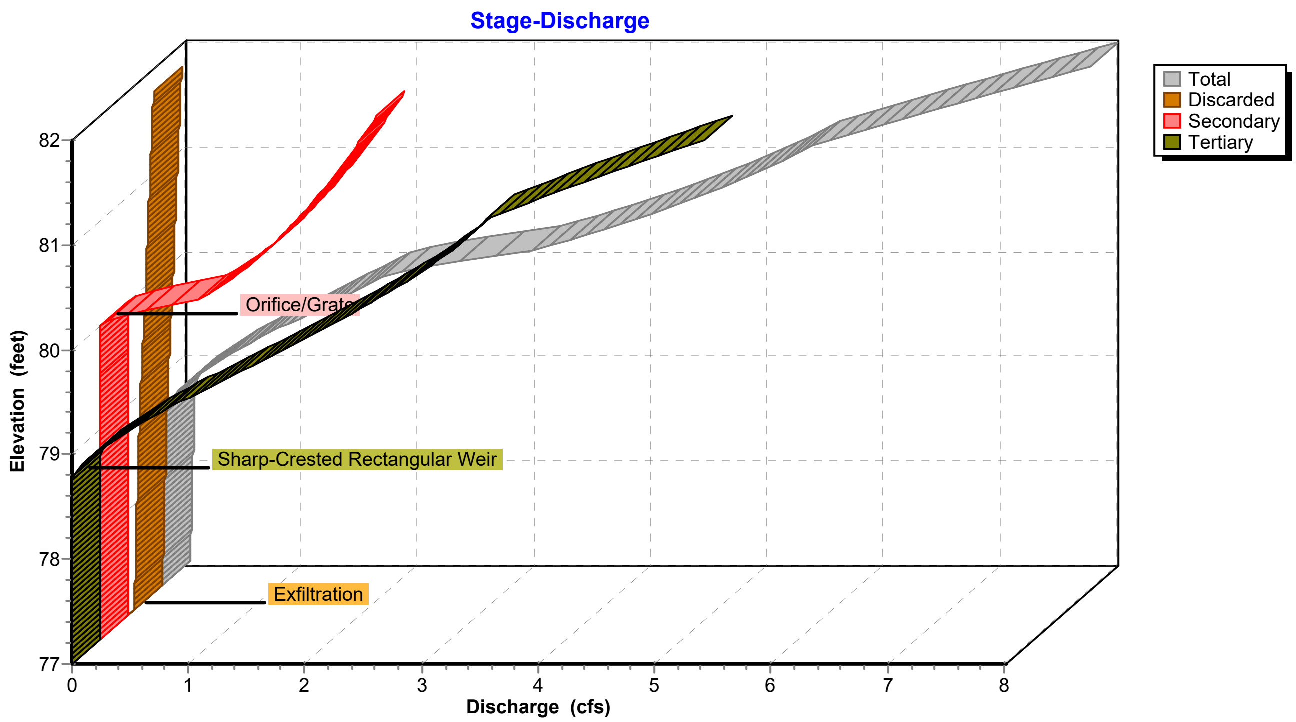
Secondary OutFlow Max=1.37 cfs @ 12.28 hrs HW=80.66' (Free Discharge)
└—**2=Orifice/Grate** (Orifice Controls 1.37 cfs @ 3.91 fps)

Tertiary OutFlow Max=2.87 cfs @ 12.28 hrs HW=80.66' (Free Discharge)
└—**3=Sharp-Crested Rectangular Weir** (Weir Controls 2.87 cfs @ 4.87 fps)

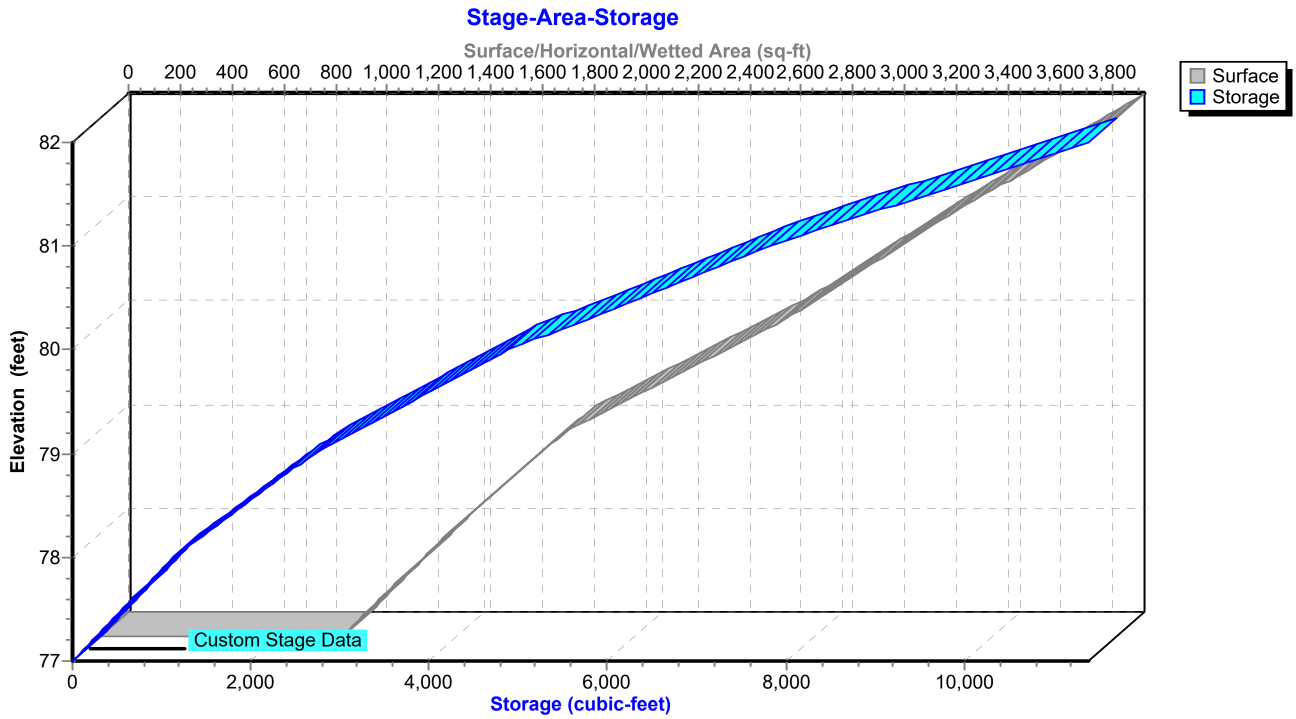
Pond 17P: Basin #1



Pond 17P: Basin #1



Pond 17P: Basin #1



Summary for Pond 21P: Basin #2

Inflow Area = 0.178 ac, 57.09% Impervious, Inflow Depth = 5.59" for 100-Year event
Inflow = 0.97 cfs @ 12.14 hrs, Volume= 0.083 af
Outflow = 0.94 cfs @ 12.17 hrs, Volume= 0.083 af, Atten= 3%, Lag= 1.6 min
Discarded = 0.02 cfs @ 12.17 hrs, Volume= 0.027 af
Secondary = 0.92 cfs @ 12.17 hrs, Volume= 0.056 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 74.77' @ 12.17 hrs Surf.Area= 821 sf Storage= 433 cf

Plug-Flow detention time= 88.2 min calculated for 0.083 af (100% of inflow)
Center-of-Mass det. time= 88.5 min (878.5 - 790.1)

Volume	Invert	Avail.Storage	Storage Description
#1	74.00'	612 cf	**Custom Stage Data (Conic)**Listed below

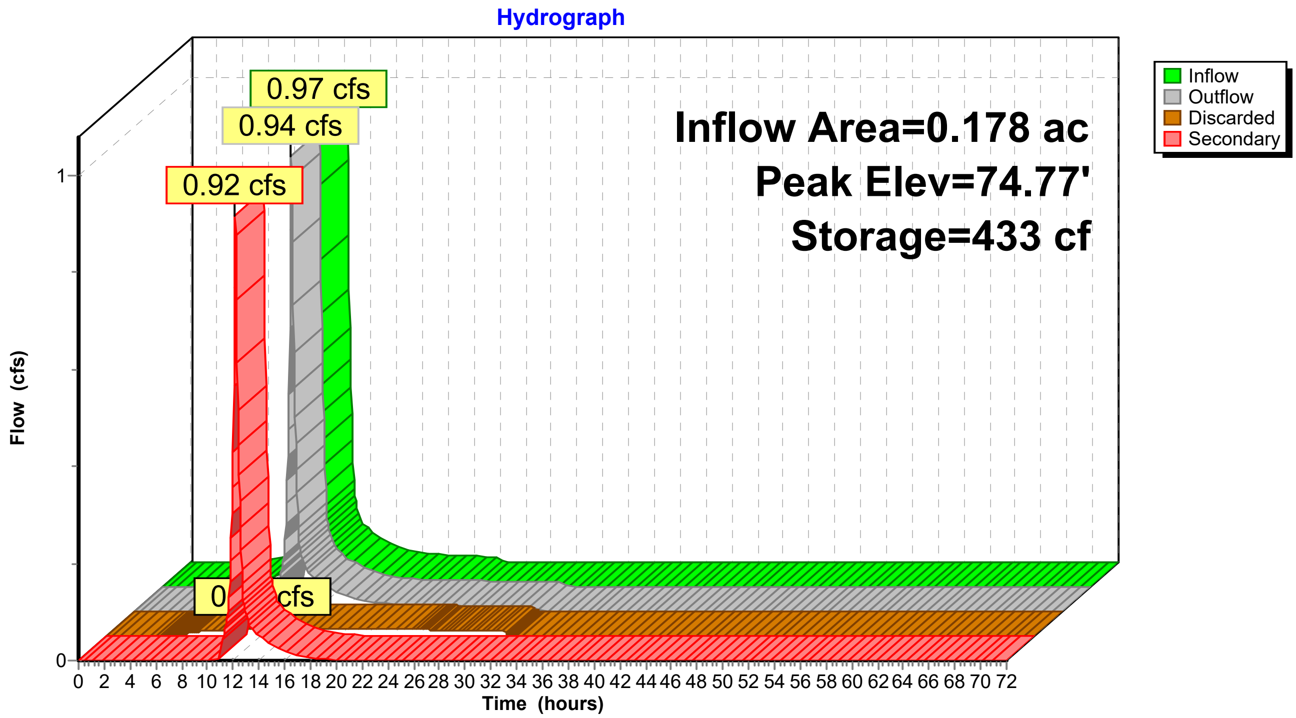
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
74.00	379	0	0	379
74.50	513	222	222	518
75.00	1,081	390	612	1,088

Device	Routing	Invert	Outlet Devices
#1	Discarded	74.00'	**1.020 in/hr Exfiltration over Wetted area**
#2	Secondary	74.60'	**4.0' long x 1.00' rise Sharp-Crested Rectangular Weir** 1 End Contraction(s)

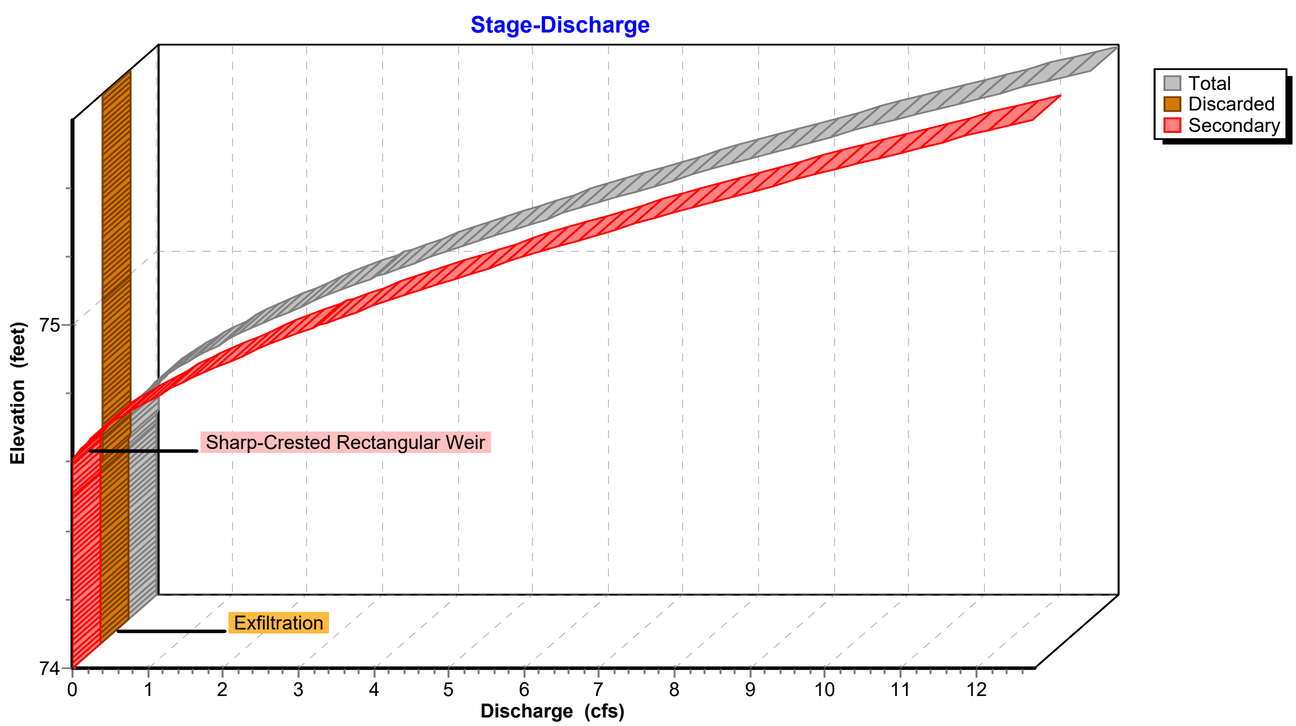
Discarded OutFlow Max=0.02 cfs @ 12.17 hrs HW=74.77' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Secondary OutFlow Max=0.90 cfs @ 12.17 hrs HW=74.77' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.90 cfs @ 1.34 fps)

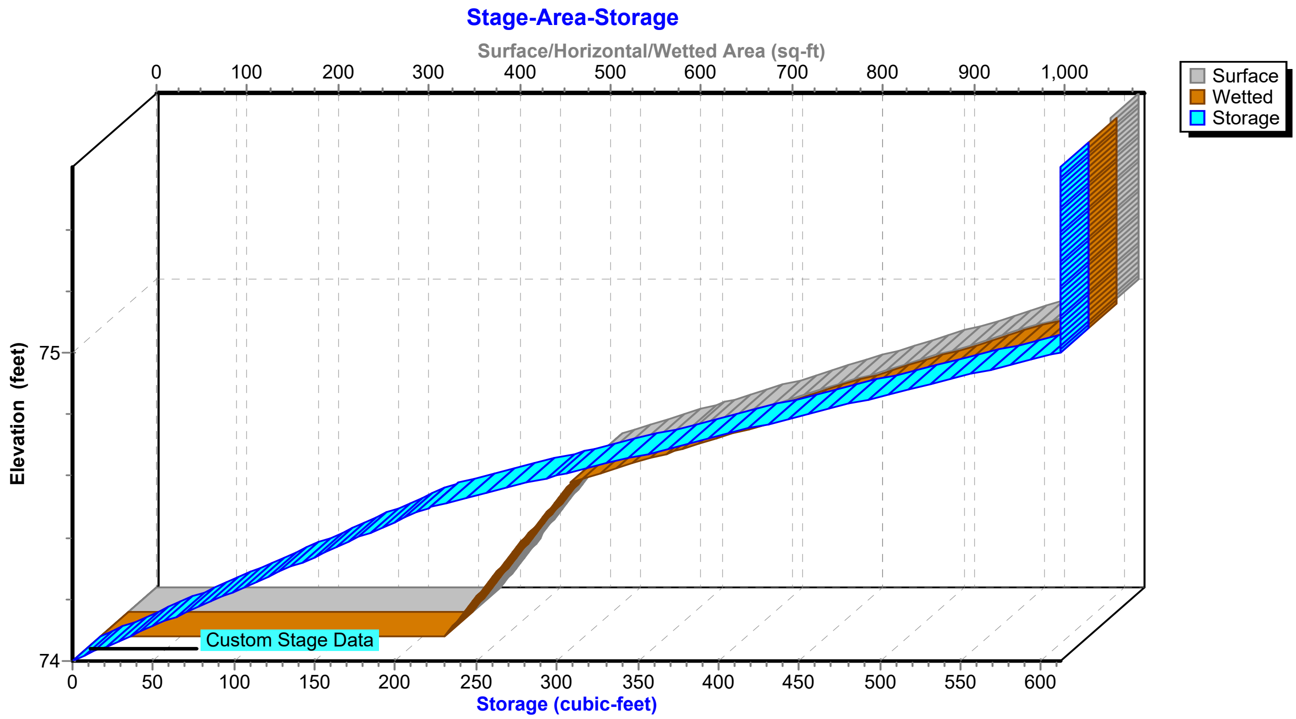
Pond 21P: Basin #2



Pond 21P: Basin #2



Pond 21P: Basin #2



Summary for Pond 25P: Subsurface infiltration

Inflow Area = 0.115 ac,100.00% Impervious, Inflow Depth = 6.76" for 100-Year event
Inflow = 0.68 cfs @ 12.14 hrs, Volume= 0.065 af
Outflow = 0.24 cfs @ 12.46 hrs, Volume= 0.065 af, Atten= 64%, Lag= 19.5 min
Discarded = 0.05 cfs @ 12.46 hrs, Volume= 0.058 af
Primary = 0.20 cfs @ 12.46 hrs, Volume= 0.007 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 84.39' @ 12.46 hrs Surf.Area= 0.008 ac Storage= 0.026 af

Plug-Flow detention time= 217.2 min calculated for 0.065 af (100% of inflow)
Center-of-Mass det. time= 217.2 min (963.8 - 746.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	79.00'	0.010 af	**10.80'W x 34.00'L x 5.50'H Field A** 0.046 af Overall - 0.022 af Embedded = 0.025 af x 40.0% Voids
#2A	80.00'	0.016 af	**Concrete Galley 4x4x4** x 16 Inside #1 Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf 2 Rows of 8 Chambers
		0.026 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	79.00'	**2.410 in/hr Exfiltration over Wetted area**
#2	Primary	84.00'	**4.0" Vert. Orifice/Grate** C= 0.600

Discarded OutFlow Max=0.05 cfs @ 12.46 hrs HW=84.38' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=0.19 cfs @ 12.46 hrs HW=84.38' (Free Discharge)
↑—**2=Orifice/Grate** (Orifice Controls 0.19 cfs @ 2.23 fps)

Pond 25P: Subsurface infiltration - Chamber Wizard Field A

Chamber Model = Concrete Galley 4x4x4 (Concrete Galley, UCPI 4x4x4 Galley or equivalent)
Inside= 42.0"W x 43.0"H => 12.67 sf x 3.50'L = 44.3 cf
Outside= 52.8"W x 48.0"H => 14.72 sf x 4.00'L = 58.9 cf

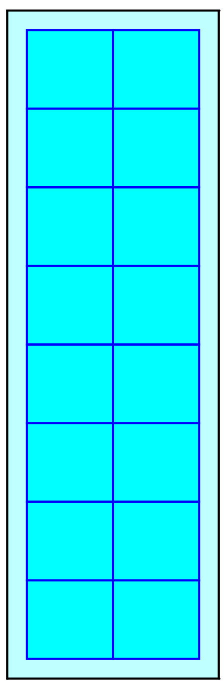
8 Chambers/Row x 4.00' Long = 32.00' Row Length +12.0" End Stone x 2 = 34.00' Base Length
2 Rows x 52.8" Wide + 12.0" Side Stone x 2 = 10.80' Base Width
12.0" Base + 48.0" Chamber Height + 6.0" Cover = 5.50' Field Height

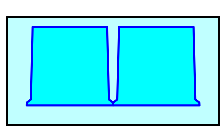
16 Chambers x 44.3 cf = 709.5 cf Chamber Storage
16 Chambers x 58.9 cf = 942.0 cf Displacement

2,019.6 cf Field - 942.0 cf Chambers = 1,077.6 cf Stone x 40.0% Voids = 431.0 cf Stone Storage

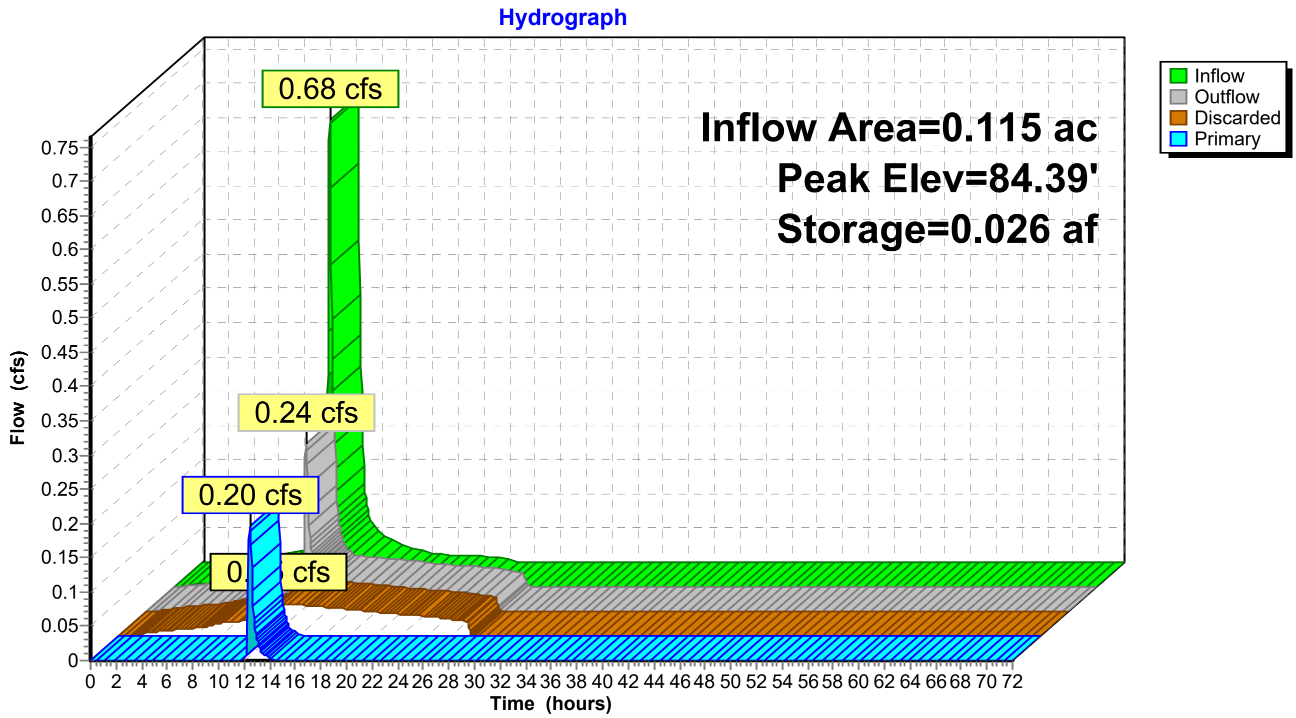
Chamber Storage + Stone Storage = 1,140.5 cf = 0.026 af
Overall Storage Efficiency = 56.5%
Overall System Size = 34.00' x 10.80' x 5.50'

16 Chambers @ $ 300.00 /ea = $ 4,800.00
74.8 cy Field Excavation @ $ 10.00 /cy = $ 748.00
39.9 cy Stone @ $ 30.00 /cy = $ 1,197.31
Total Cost = $ 6,745.31

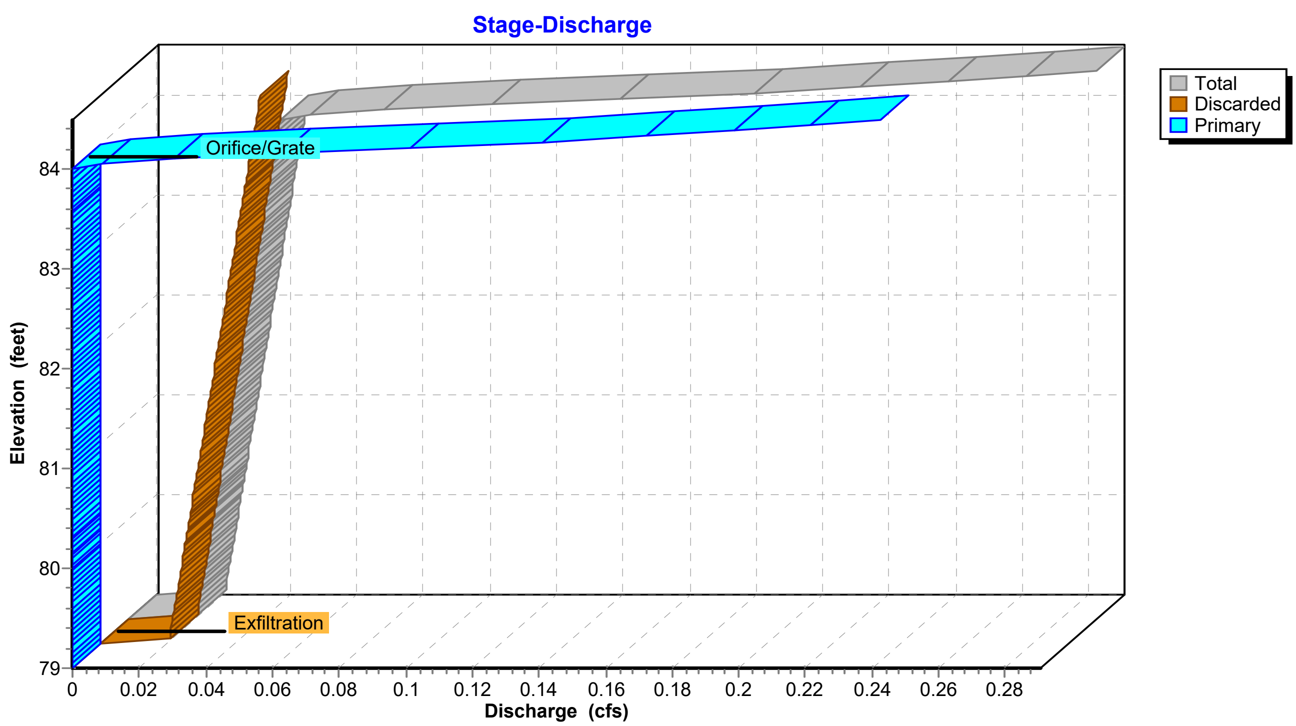




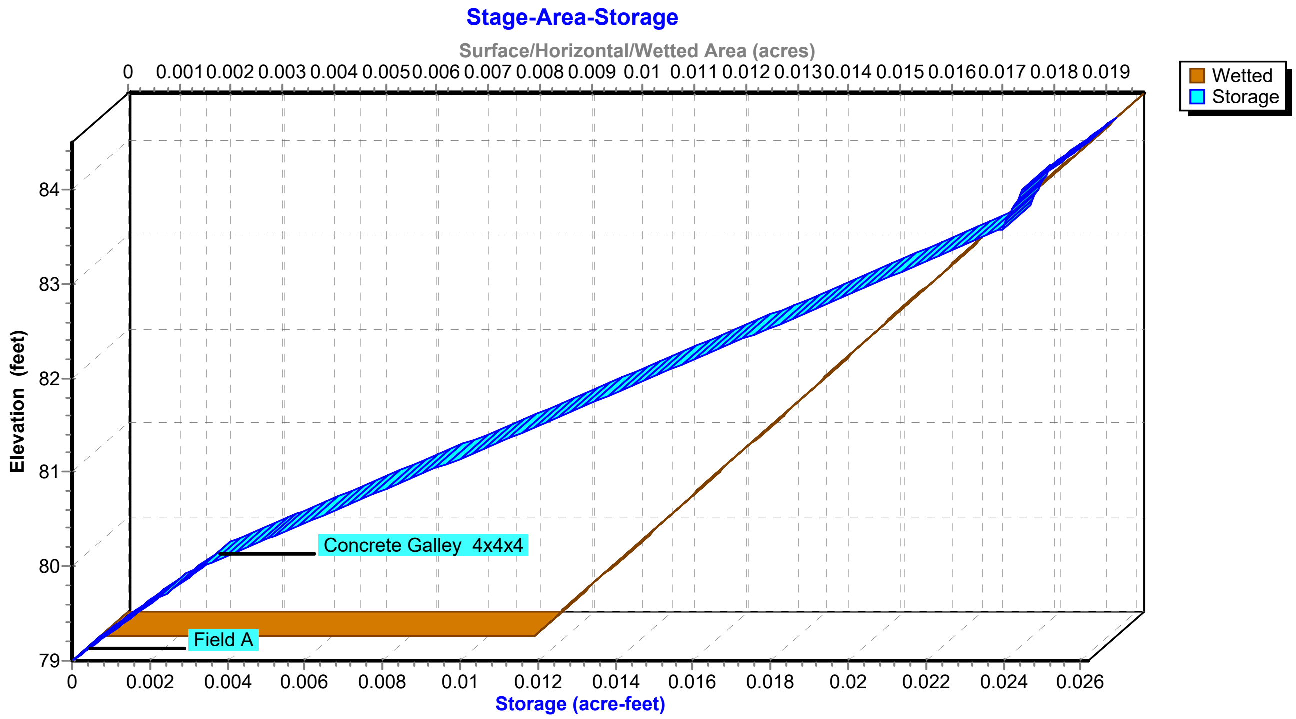
Pond 25P: Subsurface infiltration



Pond 25P: Subsurface infiltration



Pond 25P: Subsurface infiltration

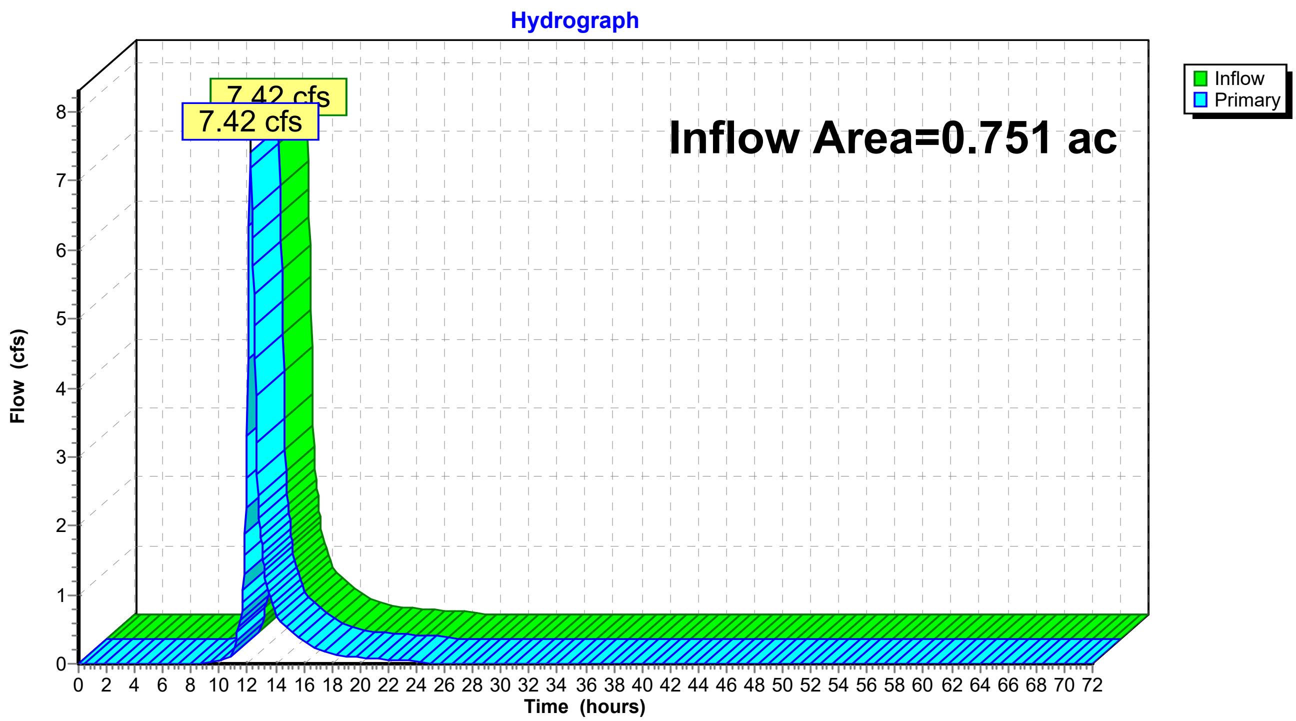


Summary for Link 23L: (Combined Link)

Inflow Area = 0.751 ac, 0.00% Impervious, Inflow Depth = 11.23" for 100-Year event
Inflow = 7.42 cfs @ 12.18 hrs, Volume= 0.702 af
Primary = 7.42 cfs @ 12.18 hrs, Volume= 0.702 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Link 23L: (Combined Link)



Section II
Stormwater Compliance

Checklist for Stormwater Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Stormwater Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

To ensure that the Stormwater Report is complete, applicants are required to fill in the Stormwater Report Checklist by checking the box to indicate that the specified information has been included in the Stormwater Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Report Checklist and Certification must be submitted with the Stormwater Report.

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[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue an Order of Conditions that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature

Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

☒ No disturbance to any Wetland Resource Areas

☒ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☐ Reduced Impervious Area (Redevelopment Only)

☐ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

- ☐ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☐ Use of "country drainage" versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☐ Other (describe): ______________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist (continued)

Standard 3: Recharge (continued)

☒ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☒ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☒ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

  ☐ is within the Zone II or Interim Wellhead Protection Area

  ☐ is near or to other critical areas

  ☒ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

  ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

- ☒ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☒ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☐ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☒ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☒ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

- ♦ **Standard 1: No New Untreated Discharges**
  The proposed development proposes no new stormwater conveyances that discharge untreated stormwater off-site or cause down gradient erosion.

- ♦ **Standard 2: Peak Rate Attenuation**
  The overall site analysis demonstrates that the stormwater management system has been designed so that the post-development peak discharge rates do not exceed the pre-development discharge rate for the 2-year, 10-year, 25-year & 100-year 24-hour storm events.

- ♦ **Standard 3: Recharge**

<u>Required Recharge Volume</u>

R_v = F x Total Impervious Area
The site is comprised of Group C Soils, according to NRCS soils Mapping
F (Target Depth Factor) = 0.25"

Required Recharge Volume Rv=F x Imp Area	(Impervious SF)	(1/12)	Target Factor	Rv
Basin #1	27582	0.0833	0.25	574.6
Basin #1	4427	0.0833	0.25	92.2
			Total	666.9

<u>Design Recharge Volume</u>

Infiltration Basin #1 = 2276 CF (Volume below outlet 78.75)
Infiltration Basin #2 = 223 CF (Volume below outlet 74.60)

<u>Drawdown Within 72 Hours</u>

$$\boldsymbol{Time_{drawdown}} = \frac{\boldsymbol{Rv}}{(\boldsymbol{K})(\boldsymbol{Bottom\ Area})}$$

Where:
Rv = Storage Volume (required recharge volume)
K = Saturated Hydraulic Conductivity For "Static" and "Simple Dynamic" Methods, use Rawls Rate (see Table 2.3.3). For "Dynamic Field" Method, use 50% of the in-situ saturated hydraulic conductivity.
Bottom Area = Bottom Area of Recharge Structure

Infiltration Basin#1: $\boldsymbol{Time_{drawdown}} = \frac{2276\ CF}{(2.41")(1'/12")(934SF)}$ = 12.1 hours < 72 hours

Infiltration Basin#2: $\boldsymbol{Time_{drawdown}} = \frac{223\ CF}{(1.02")(1'/12")(379SF)}$ = 6.9 hours < 72 hours

Mounding Analysis

"Mounding analysis is required when the vertical separation from the bottom of an exfiltration system to seasonal high groundwater is less than four (4) feet and the recharge system is proposed to attenuate the peak discharge from a 10-year or higher 24-hour storm (e.g., 10-year, 25-year, 50-year, or 100-year 24-hour storm). In such cases, the mounding analysis must demonstrate that the Required Recharge Volume (e.g., infiltration basin storage) is fully dewatered within 72 hours (so the next storm can be stored for exfiltration). The mounding analysis must also show that the groundwater mound that forms under the recharge system will not break out above the land or water surface of a wetland (e.g., it doesn't increase the water sheet elevation in a Bordering Vegetated Wetland, Salt Marsh, or Land Under Water within the 72-hour evaluation period)."

"The Hantush[1] or other equivalent method may be used to conduct the mounding analysis. The Hantush method predicts the maximum height of the groundwater mound beneath a rectangular or circular recharge area. It assumes unconfined groundwater flow, and that a linear relation exists between the water table elevation and water table decline rate. It results in a water table recession hydrograph depicting exponential decline. The Hantush method is available in proprietary software and free on-line calculators on theWeb in automated format. If the analysis indicates the mound will prevent the infiltration BMP from fully draining within the 72-hour period, an iterative process must be employed to determine an alternative design that drains within the 72-hour period."

A mounding calculation is not required since groundwater is greater than four feet below the bottom of the basin.
Mounding analysis is required when the vertical separation from the bottom of the exfiltration system to seasonal high groundwater is less than 4 ft. The mounding analysis must show that the groundwater mound that forms under the recharge system will not breakout above the land.

Mounding

System	Bottom El	Groundwater el	Separation (FT)	
Basin #1	77.0	73.1 (TH D-1)	3.9	(mounding required)
Basin #2	74.0	72.0 (assumed)	2.00	(mounding required)

Recharge Rate (Rr) = (volume retained below low outlet/WQV)/ (bottom area)

Rr Basin #1 = 2276 / 934 = 2.43
Rr Basin #2 = 226 / 379 = 0.56

[1] Hantush 1967 – See Reference for Standard 3.

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = y). For a rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin.
Users can change the distances from the center of the basin at which water-table aquifer thickness are calculated.
Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. The user MUST click the blue "Re-Calculate Now" button each time ANY of the user-specified inputs are changed otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

use consistent units (e.g. feet & days **or** inches & hours)

Input Values

2.4300	***R***	**Recharge (infiltration) rate (feet/day)**
0.260	**Sy**	**Specific yield, Sy (dimensionless, between 0 and 1)**
3.00	**K**	**Horizontal hydraulic conductivity, Kh (feet/day)***
24.000	**x**	**1/2 length of basin (x direction, in feet)**
12.500	**y**	**1/2 width of basin (y direction, in feet)**
1.000	**t**	**duration of infiltration period (days)**
50.000	**hi(0)**	**initial thickness of saturated zone (feet)**

Conversion Table

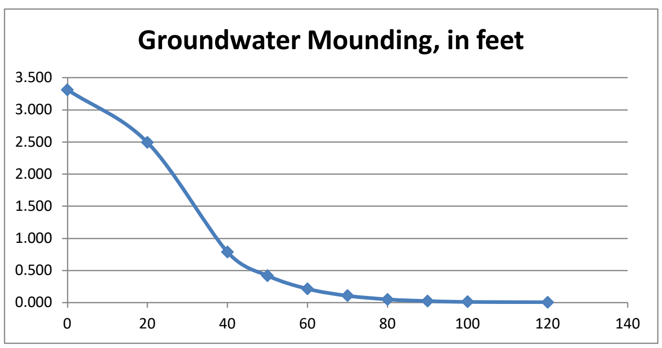
inch/hour	**feet/day**
0.67	1.33
2.00	4.00
hours	**days**
36	1.50

In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).

53.312	**h(max)**	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
3.312	**Δh(max)**	**maximum groundwater mounding (beneath center of basin at end of infiltration period)**

Ground-water Mounding, in feet	**Distance from center of basin in x direction, in feet**
3.312	**0**
2.493	**20**
0.787	**40**
0.419	**50**
0.215	**60**
0.106	**70**
0.050	**80**
0.023	**90**
0.011	**100**
0.004	**120**

Re-Calculate Now



Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = y). For a rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can change the distances from the center of the basin at which water-table aquifer thickness are calculated.
Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. The user MUST click the blue "Re-Calculate Now" button each time ANY of the user-specified inputs are changed otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

use consistent units (e.g. feet & days **or** inches & hours)

Input Values		
0.5600	***R***	**Recharge (infiltration) rate (feet/day)**
0.260	**Sy**	**Specific yield, Sy (dimensionless, between 0 and 1)**
3.00	**K**	**Horizontal hydraulic conductivity, Kh (feet/day)***
13.000	**x**	**1/2 length of basin (x direction, in feet)**
9.000	**y**	**1/2 width of basin (y direction, in feet)**
1.000	**t**	**duration of infiltration period (days)**
50.000	**hi(0)**	**initial thickness of saturated zone (feet)**

Conversion Table

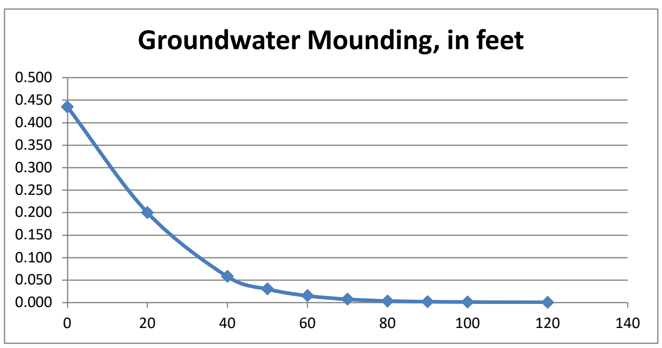
inch/hour	**feet/day**
0.67	1.33
2.00	4.00
hours	**days**
36	1.50

In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).

50.435	**h(max)**	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
0.435	**Δh(max)**	**maximum groundwater mounding (beneath center of basin at end of infiltration period)**

Ground-water Mounding, in feet	**Distance from center of basin in x direction, in feet**
0.435	**0**
0.200	**20**
0.058	**40**
0.030	**50**
0.015	**60**
0.007	**70**
0.004	**80**
0.002	**90**
0.001	**100**
0.001	**120**

Re-Calculate Now



Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.

Basin #1 using the Hantush Method, 934 s.f. bottom area, volume = 2276, recharge infiltration rate of 2.43 ft/day and an initial saturated thickness of 50 feet, we calculated a groundwater mounding of 3.2 feet. Groundwater separation = 3.3 ft mounding will not breakout above the land or interfere with infiltration

Basin #2 using the Hantush Method, 397 s.f. bottom area, volume = 226, recharge infiltration rate of 0.56 ft/day and an initial saturated thickness of 50 feet, we calculated a groundwater mounding of 2.19 feet. Groundwater separation = 0.45 ft mounding will not breakout above the land or interfere with infiltration

♦ Standard 4: Water Quality

<u>Water Quality Treatment Volume</u>

$V_{WQ} = D_{WQ} \times A_{IMP}$

D_{WQ} = *Water Quality Depth*: **one-inch** for land use with a higher potential pollutant load, within an area with an **infiltration rate greater than 2.4 inches per hour**, within a Zone II or Interim Wellhead Protection Area, or near or to another critical area; one-half-inch for all other areas.

A_{IMP} = *Impervious Area*

D_{WQ} = 1”

Required	(Impervious SF)	(1/12)	DWQ	(CF)	volume below outlet (CF)	
WQV Basin #1	27582	0.0833	1	2298	2267	provided at el=78.75 (lowest outlet)
WQV Basin #2	4427	0.0833	1	369	223	provided at el=75.6 (lowest outlet)
WQV Roof system	5000	0.0833	1	417	1045	provided at el=84.00 (lowest outlet)
WQV Total	37009	0.083333	0.5	1542	1543	

- **Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLS)**
  The site is not a land use with higher potential pollutant loads.

- **Standard 6: Critical Areas**
  The site is not located within an aquifer protection Zone II or Interim Wellhead Protection Area.

- **Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable**
  The project is not a redevelopment project.

- **Standard 8: Construction Period Pollution Prevention and Erosion and Sediment Control Plan**
  An operation and maintenance plan has been prepared and Erosion and sediment controls are detailed within the site plan.

- **Standard 9: Operation and Maintenance Plan**
  See O&M plan attached hereto.

- **Standard 10: Prohibition of Illicit Discharges**
  "All illicit discharges to the stormwater management system are prohibited."

  This statement is intended to meet Standard #10 of the Stormwater Management requirements

  Illicit discharges to the stormwater management system are discharges that are not entirely comprised of stormwater.

  Except for the potential for deliberate criminal act of discharge by an unauthorized entity for which the property owner has no control, there are to be no illicit discharges into the stormwater system.

____

Applicant\Owner

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Basin #1 & 2Pretreatment

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**0.25**	**1.00**	**0.25**	**0.75**
Sediment Forebay	**0.25**	**0.75**	**0.19**	**0.56**
	0.00	**0.56**	**0.00**	**0.56**
	0.00	**0.56**	**0.00**	**0.56**
	0.00	**0.56**	**0.00**	**0.56**

Total TSS Removal = 44%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: 120-365
Prepared By: KG
Date: 12/18/2020

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Basin #1 & 2

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	0.25	1.00	0.25	0.75
Sediment Forebay	0.25	0.75	0.19	0.56
Infiltration Basin	0.80	0.56	0.45	0.11
	0.00	0.11	0.00	0.11
	0.00	0.11	0.00	0.11

Total TSS Removal = 89%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: 20-365
Prepared By: KG
Date: 12/18/2020

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

OVERFLOW SPILLWAY DESIGN - INFILTRATION BASIN #1

Job No.: 20-365
Location: George Thibeault

- Design Spillway for Q_{100} into Basin

Q_{100} = 6.92 cfs

- Length of Spillway = 8 ft

- Set Spillway Elevation 0.1 Above 100 Year Level of Basin

100 Year Level =	80.66
Feet above 100 Year Level=	0
	80.66
Use Spillway Elevation =	80.66

- Set Top of Berm 1 feet Above 100 Year Spillway Surface

$Q = CLH^{3/2}$

Q = Discharge Over Broad Crested Weir
C = 2.7 Handbook of Hydraulics p. 5-40, King & Brater
L = Length of Weir
H = Head on Weir

$H = (Q/CL)^{2/3}$

$H = 6.92 / (2.7*8)^{2/3}$ = 0.47

Top of Berm Elevation = 80.66 + 0.47 = 81.13 min

Use 81.66

OVERFLOW SPILLWAY DESIGN - INFILTRATION BASIN #2

Job No.: 20-365
Location: George Thibeault

- Design Spillway for Q_{100} into Basin

Q_{100} = 0.97 cfs

- Length of Spillway = 8 ft

- Set Spillway Elevation 0.1 Above 100 Year Level of Basin

100 Year Level =	74.77
Feet above 100 Year Level=	0
	74.77
Use Spillway Elevation =	74.77

- Set Top of Berm 1 feet Above 100 Year Spillway Surface

$Q = CLH^{3/2}$

Q = Discharge Over Broad Crested Weir
C = 2.7 Handbook of Hydraulics p. 5-40, King & Brater
L = Length of Weir
H = Head on Weir

$H = (Q/CL)^{2/3}$

$H = 0.97 / (2.7*8)^{2/3}$ = 0.13

Top of Berm Elevation = 74.77 + 0.13 = 74.90 min

Use 75.77

Section III

Operation & Maintenance

OPERATION AND MAINTENANCE PLAN

PROPOSED DRAINAGE SYSTEM – DURING CONSTRUCTION

715 Washington Street
Pembroke, Massachusetts

Owner:
George Thibeault
599 Summer Street
Marshfield MA 02050
Contact: George Thibeault 781-789-7555 wildlandtimber@gmail.com

Party Responsible for Operation and Maintenance:
George Thibeault
599 Summer Street
Marshfield MA 02050
Contact: George Thibeault 781-789-7555 wildlandtimber@gmail.com

Source of Funding:

Operation and Maintenance of this stormwater management system will be the responsibility of the property owner to include its successor and/or assigns, as the same may appear on record with the appropriate register of deeds.

During Construction:

During periods of active construction the stormwater management system shall be inspected on a weekly basis and within 24 hours of a storm event of greater than ½". Maintenance tasks shall be performed monthly or after significant rainfall events of 1" of rain or greater. During construction, silt-laden runoff shall be prevented from entering the drainage system and off-site properties. Temporary swales shall be constructed as needed during construction to direct runoff to sediment traps. Infiltration systems shall not be placed in service until after the installation of base course pavement and vegetative stabilization of the areas contributing to the systems.

During dewatering operations, all water pumped from the dewatering shall be directed to a "dirt bag" pumped sediment removal system (or approved equal) as manufactured by ACF Environmental. The unit shall be placed on a crushed stone blanket. Disposal of such "dirt bag" shall occur when the device is full and can no longer effectively filter sediment or allow water to pass at a reasonable flow rate. Disposal of this unit shall be the responsibility of the contractor and shall be as directed by the owner in accordance with applicable local, state, and federal guidelines and regulations.

Stabilized construction entrances shall be placed at the entrances and shall consist of 1½“ to 2” stone and be constructed as shown on the approved plans.

All erosion and sedimentation control measures shall be in place prior to the commencement of any site work or earthwork operations, and shall be maintained during construction, and shall remain in place until all site work is complete and ground cover is established.

Heavy equipment shall not be used on basin bottoms.

All exposed soils not to be paved shall be stabilized as soon as practical. Seed mixes shall only be applied during appropriate periods as recommended by the seed supplier, typically May 1 to October 15. Any exposed soils that cannot be stabilized by vegetation during these dates shall be stabilized with hay bales, hay mulch, check dams, jute netting or other acceptable means.

Once each structure is in place, it should be maintained in accordance with the procedures described in the post-construction Operations and Maintenance Plan.

During dry periods where dust is created by construction activities the following control measures should be implemented.

- Sprinkling – The contractor may sprinkle the ground along haul roads and traffic areas until moist.
- Vegetative cover – Areas that are not expected to be disturbed regularly may be stabilized with vegetative cover.
- Mulch – Mulching can be used as a quick and effective means of dust control in recently disturbed areas.
- Spray on chemical soil treatments may be utilized. Application rates shall conform to manufacturers recommendations.

For additional information, refer to Performance, Standards and Guidelines for Stormwater Management in Massachusetts, published by the Department of Environmental Protection.

STORMWATER MANAGEMENT
BEST MANAGEMENT PRACTICES
INSPECTION SCHEDULE AND EVALUATION CHECKLIST – CONSTRUCTION PHASE

PROJECT LOCATION: 715 Washington Street, Pembroke
Latest Revision: 12/18/20

Stormwater Control Manager: _____ **Stamp**

Best Management Practice	Inspection Frequency (1)	Date Inspected	Inspector	Minimum Maintenance and Key Items to Check	Cleaning/ Repair Needed yes/no List items	Date of Cleaning/Repair	Performed By	Water Level in Detention System
Silt socks & swales and silt traps	After every major storm event							
Dewatering Operations	Daily- during actual dewatering							
Temporary Construction Entrance	Daily or as needed.							

(1) Refer to the Massachusetts Stormwater Management, Volume Two: Stormwater Technical Handbook for recommendations regarding frequency for inspection and maintenance of specific BMPs.

Limited or no use of sodium chloride salts, fertilizers or pesticides recommended. Slow release fertilizer recommended.
Other notes:(Include deviations from: Con Com Order of Conditions, PB Approval, Construction Sequence and Approved Plan)

OPERATION AND MAINTENANCE PLAN
PROPOSED DRAINAGE SYSTEM – POST CONSTRUCTION
715 Washington Street
Pembroke, Massachusetts

Owner:
George Thibeault
599 Summer Street
Marshfield MA 02050
Contact: George Thibeault 781-789-7555 wildlandtimber@gmail.com

Party Responsible for Operation and Maintenance:

After construction is complete the owner will be the party responsible for operation and maintenance of the drainage system. When the property is conveyed, the new owner will be the party responsible for operation and maintenance.

Source of Funding:

Operation and Maintenance of this stormwater management system will be the responsibility of the owner. The estimated annual budget for the operation and maintenance of the stormwater system is $1000.

Schedule for Inspection and Maintenance:

Deep Sump Catch Basins
Deep sump catch basins shall become part of the roadway system and shall be inspected after every major storm event during construction and cleaned when sediment exceeds 18" depth. After construction when all slopes have been stabilized, basins shall be cleaned a minimum of twice per year. Disposal of the accumulated sediment shall be in accordance with applicable local, state, and federal guidelines and regulations.

Sediment Forebays (at grade)
At a minimum, inspect sediment forebays monthly and clean them out at least four times per year. Stabilize the floor and sidewalls of the sediment forebay before making it operational. When mowing grasses, keep the grass height lower than 6 inches, check for signs of riling and gullying and repair as needed. After removing sediment, replace any vegetation damaged during the clean-out by re-seeding or sodding. When re-seeding, incorporate practices such as hydro seeding with a tackifier, blanket or similar practice to ensure that no scour occurs in the forebay, while the seeds germinate and develop roots.

Any sediment removed from the infiltration systems should be disposed of in accordance with Town, State and Federal Regulations.

Infiltration Basin
The Infiltration BMP's should be inspected on a quarterly basis: additional inspections should be scheduled during the first few months to make sure the vegetation is established adequately and also following major storm events. Additional inspections are required following any storm event that exceeds 2.5 inches in 24-hour period (the one-year frequency storm). Evidence of standing water for more than 48 hours following a storm would indicate possible failure of the infiltration surface. In that case, a qualified professional engineer should be retained to assess the

cause of failure and recommend corrective action, which should be immediately implemented to restore the function of the system. The basin should be inspected for slope integrity, soil moisture, vegetative health, soil stability, soil compaction, soil erosion, ponding and sedimentation. The basin should be mowed twice per year.

Regular maintenance tasks include mowing, watering, and weed and pest control. Only organic fertilizers, weed and pest control will be utilized.

Sediment and debris should be removed manually, at least twice per year, before the vegetation is impacted adversely. Periodic mowing (Twice per year) may be required to maintain the dense growth of vegetation. Care should be taken to protect basin from snow removal procedures and off street parking.

Subsurface Drainage Systems Maintenance Schedule (Roof)

Activity Time of Year Frequency

Inspect Inlets and access manholes twice per year. Remove any debris that might clog the system.

After construction, the systems should be inspected for standing water 1-2 days after any significant rainfall exceeding 1” of rainfall in 24 hours or major storm event. If the system is continuing to hold standing water after 2 days the owner should have it inspected and repaired. The systems should also be inspected to verify whether infiltration function has been lost. If infiltration capacity has become degraded, it should be restored under the direction of a qualified professional.

The subsurface systems should be inspected twice per year and at least once per year by a drainage system professional to ensure that the system is operating as intended. The owner shall implement and pay for the inspector’s recommendations.

Lawn Fertilization

Lawn fertilizer shall be slow release and limited to 3 lbs per 1000 s.f. per year.

Stormwater Contamination Prevention

Exterior storage of hazardous materials including deicing chemicals, fertilizers, herbicides, pesticides, and other hazardous materials is prohibited. All hazardous materials are to be stored inside of the buildings no exterior storage of hazardous materials is allowed. Individual storage unit users shall be notified of the prohibition of illicit discharges to the stormwater management system.

Illicit Discharges

Illicit discharges to the stormwater management system are discharges that are not entirely comprised of stormwater. Illicit discharges are prohibited from the stormwater management system and the stormwater management system shall be inspected for illicit discharges annually.

The following is a list of discharges that are allowed under the EPA Construction General Permit (CGP) provided that appropriate stormwater controls are designed, installed, and maintained:

a. Stormwater discharges, including stormwater runoff, snowmelt runoff, and surface runoff and drainage, associated with construction activity under 40 CFR §122.26(b)(14) or § 122.26(b)(15)(i);

b. Stormwater discharges designated by EPA as needing a permit under 40 CFR § 122.26(a)(1)(v) or §122.26(b)(15)(ii);

c. Stormwater discharges from construction support activities *(e.g., concrete or asphalt batch plants, equipment staging yards, material storage areas, excavated material disposal areas, borrow areas)* provided:

i. The support activity is directly related to the construction site required to have permit coverage for stormwater discharges;
ii. The support activity is not a commercial operation, nor does it serve multiple unrelated construction projects;
iii. The support activity does not continue to operate beyond the completion of the construction activity at the project it supports; and
iv. Stormwater controls are implemented in accordance with Part 2 of the CGP and, if applicable, Part 3 of the CGP, for discharges from the support activity areas.

The following non-stormwater discharges from your construction activity, provided that, with the exception of water used to control dust and to irrigate areas to be vegetatively stabilized, these discharges are not routed to areas of exposed soil on your site and you comply with any applicable requirements for these discharges in Part 2 of the CGP:
i. Discharges from emergency fire-fighting activities;
ii. Fire hydrant flushings;
iii. Landscape irrigation;
iv. Water used to wash vehicles and equipment, provided that there is no discharge of soaps, solvents, or detergents used for such purposes;
v. Water used to control dust;
vi. Potable water including uncontaminated water line flushings;
vii. Routine external building washdown that does not use detergents;
viii. Pavement wash waters provided spills or leaks of toxic or hazardous materials have not occurred (unless all spill material has been removed) and where detergents are not used. You are prohibited from directing pavement wash waters directly into any surface water, storm drain inlet, or stormwater conveyance, unless the conveyance is connected to a sediment basin, sediment trap, or similarly effective control;
ix. Uncontaminated air conditioning or compressor condensate;
x. Uncontaminated, non-turbid discharges of ground water or spring water;
xi. Foundation or footing drains where flows are not contaminated with process materials such as solvents or contaminated ground water; and
xii. Construction dewatering water that has been treated by an appropriate control under Part 2.1.3.4 of the CGP; and
e. Discharges of stormwater listed above in Parts a, b, and c, or authorized nonstormwater discharges in Part d above, commingled with a discharge authorized by a different NPDES permit and/or a discharge that does not require NPDES permit authorization.

Snow Removal and De-icing

Snow removal will be the responsibility of the Owner. Snow will be plowed from Parking areas and driveways and shoveled or removed with a snow blower from walkways. Snow will be stored along roadways and walkways as shown on the Site Plan. If additional stockpiling area is needed, excess snow will be removed from the site with proper off-site disposal. Snow shall be stockpiled in areas where melting will be directed through the drainage systems and not directly to the wetlands. Stockpiling within any infiltration areas is prohibited.

Inspections

Yearly inspections of the stormwater management system shall be performed and an Inspection Schedule and Evaluation Checklist shall be maintained by the Owner and made available to regulatory officials if requested. Copies of the receipts for cleaning of the systems shall also be maintained.

The Owner shall be responsible to secure the services of a Licensed Engineer on an on-going basis. The inspector shall review the project with respect to the following:

- Proper installation and performance of the Stormwater Management System.
- Review of the controls to determine any damaged or ineffective controls.
- Corrective actions.

The Engineer shall prepare, stamp and submit, to the Owner, a report documenting the findings and should request the required maintenance or repair for the pollution prevention controls when the inspector finds that it is necessary for the control to be effective (see attached Inspection Schedule and Evaluation Checklist). The inspector shall notify the Owner to make the changes.

The owner and/or their employees responsible for the O&M of the stormwater management system shall be trained annually. Records of trained individuals shall be kept and submitted to the town with the check list. The records shall indicate the latest training date.

The attached inspection form shall be retained and kept available for a minimum of three years.

For additional information, refer to Performance, Standards and Guidelines for Stormwater Management in Massachusetts, published by the Department of Environmental Protection

Definition of Major Storm Event

For the purposes of this operation and maintenance plan a major storm event should be defined as a rainfall of such intensity or duration that causes observable movement of sediment on the roadway or site. It is the intent of this plan to prevent this sediment from entering the drainage system. Prior to stabilization of the site this may occur more frequently with less intense storms. As the site is stabilized with ground cover the movement of sediment will only occur during more severe storms.

For additional information, refer to Performance Standards and Guidelines for Stormwater Management in Massachusetts, published by the Department of Environmental Protection.

STORMWATER MANAGEMENT
BEST MANAGEMENT PRACTICES

INSPECTION SCHEDULE AND EVALUATION CHECKLIST – POST CONSTRUCTION PHASE

PROJECT LOCATION: 737 Washington Street, Pembroke
Latest Revision 1/24/20

Best Managemen t Practice	Inspection Frequency (1)	Date Inspected	Inspector	Minimum Maintenance and Key Items to Check	Cleaning/ Repair Needed yes/no List items	Date of Cleaning/ Repair	Performed By	Water Level in Drainage System
Infiltration Basin	Twice per year							
Deep sump catch basins	Twice per year							
Subsurface Roof System	Twice per year							

(1) Refer to the Massachusetts Stormwater Management, Volume Two: Stormwater Technical Handbook for recommendations regarding frequency for inspection and maintenance of specific BMPs.
(2) records shall be kept for a minimum of three years.

Limited or no use of sodium chloride salts, fertilizers or pesticides recommended. Slow release fertilizer recommended.
Other notes:(Include deviations from: Con Com Order of Conditions, PB Approval, Construction Sequence and Approved Plan)

Stormwater Control Manager: _____ **Stamp**

Deep Sump Catch Basin

Description: Deep sump catch basins, also known as oil and grease or hooded catch basins, are underground retention systems designed to remove trash, debris, and coarse sediment from stormwater runoff, and serve as temporary spill containment devices for floatables such as oils and greases.

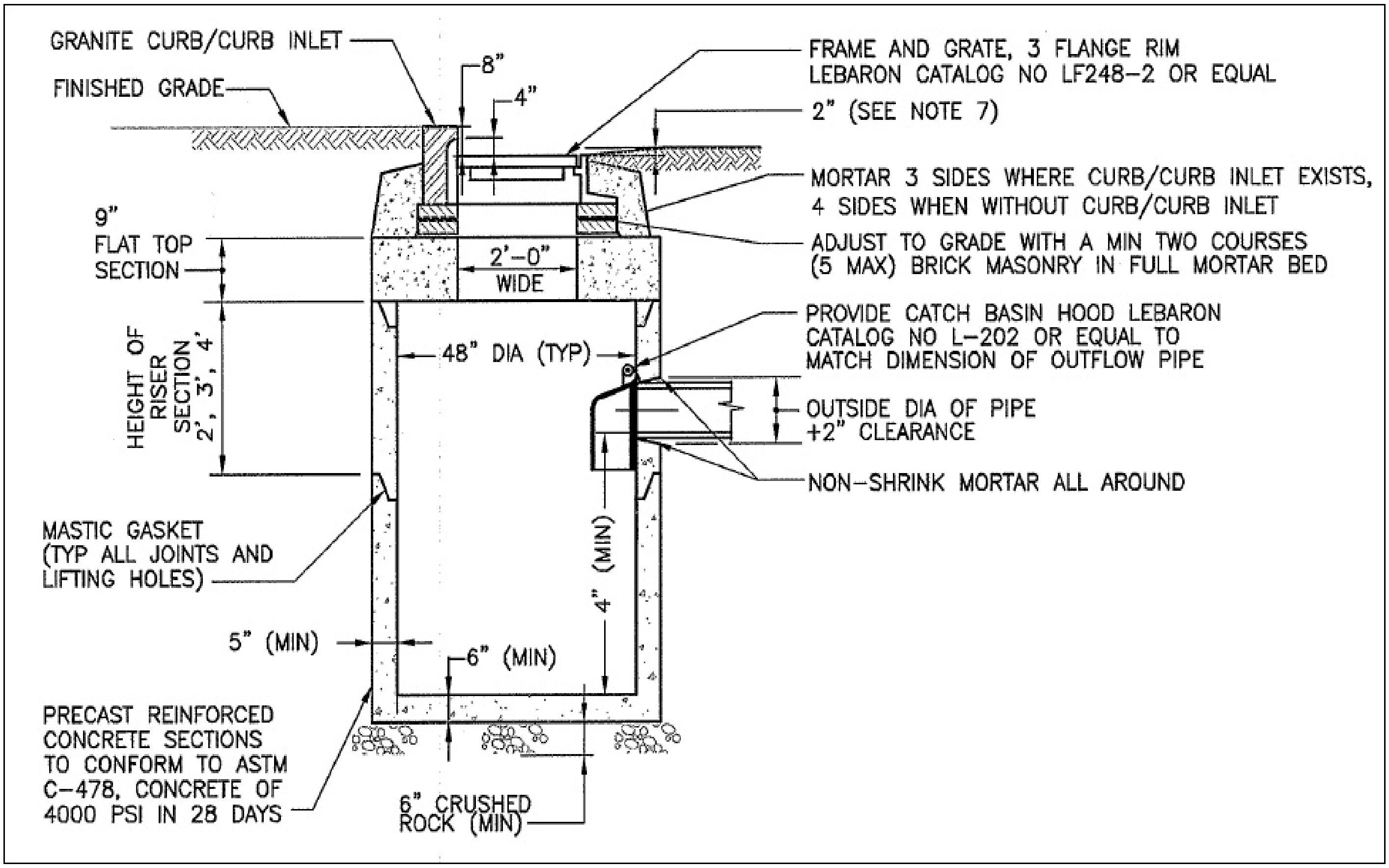
Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	25% TSS removal credit when used for pretreatment. Because of their limited effectiveness and storage capacity, deep sump catch basins receive credit for removing TSS only if they are used for pretreatment and designed as off-line systems.
5 - Higher Pollutant Loading	Recommended as pretreatment BMP. Although provides some spill control capability, a deep sump catch basin may not be used in place of an oil grit separator or sand filter for land uses that have the potential to generate runoff with high concentrations of oil and grease such as: high-intensity-use parking lots, gas stations, fleet storage areas, vehicle and/or equipment maintenance and service areas.
6 - Discharges near or to Critical Areas	May be used as pretreatment BMP. not an adequate spill control device for discharges near or to critical areas.
7 - Redevelopment	Highly suitable.

Advantages/Benefits:
- Located underground, so limited lot size is not a deterrent.
- Compatible with subsurface storm drain systems.
- Can be used for retrofitting small urban lots where larger BMPs are not feasible.
- Provide pretreatment of runoff before it is delivered to other BMPs.
- Easily accessed for maintenance.
- Longevity is high with proper maintenance.

Disadvantages/Limitations:
- Limited pollutant removal.
- Expensive to install and maintain, resulting in high cost per unit area treated.
- No ability to control volume of stormwater
- Frequent maintenance is essential
- Requires proper disposal of trapped sediment and oil and grease
- Entrapment hazard for amphibians and other small animals

Pollutant Removal Efficiencies
- Total Suspended Solids (TSS) - 25% (for regulatory purposes)
- Nutrients (Nitrogen, phosphorus) - Insufficient data
- Metals (copper, lead, zinc, cadmium) - Insufficient data
- Pathogens (coliform, e coli) - Insufficient data



adapted from the University of New Hampshire

Maintenance

Activity	Frequency
Inspect units	Four times per year
Clean units	Four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin.

Special Features

All deep sump catch basins must include hoods. For MassHighway projects, consult the Stormwater Handbook for Highways and Bridges for hood requirements.

LID Alternative

Reduce Impervious Surface
Disconnect rooftop and non-rooftop runoff
Vegetated Filter Strip

Deep Sump Catch Basin

Suitable Applications

- Pretreatment
- Residential subdivisions
- Office
- Retail

Design Considerations

- The contributing drainage area to any deep sump catch basin should not exceed ¼ acre of impervious cover.
- Design and construct deep sump catch basins as off-line systems.
- Size the drainage area so that the flow rate does not exceed the capacity of the inlet grate.
- Divert excess flows to another BMP intended to meet the water quantity requirements (peak rate attenuation) or to a storm drain system. An off-line design enhances pollutant removal efficiency, because it prevents the resuspension of sediments in large storms.

Make the sump depth (distance from the bottom of the outlet pipe to the bottom of the basin) at least four feet times the diameter of the outlet pipe and more if the contributing drainage area has a high sediment load. The minimum sump depth is 4 feet. Double catch basins, those with 2 inlet grates, may require deeper sumps. Install the invert of the outlet pipe at least 4 feet from the bottom of the catch basin grate.

The inlet grate serves to prevent larger debris from entering the sump. To be effective, the grate must have a separation between the grates of one square inch or less. The inlet openings must not allow flows greater than 3 cfs to enter the deep sump catch basin. If the inlet grate is designed with a curb cut, the grate must reach the back of the curb cut to prevent bypassing. The inlet grate must be constructed of a durable material and fit tightly into the frame so it won't be dislodged by automobile traffic. The inlet grate must not be welded to the frame so that sediments may be easily removed. To facilitate maintenance, the inlet grate must be placed along the road shoulder or curb line rather than a traffic lane.

Note that within parking garages, the State Plumbing Code regulates inlet grates and other stormwater management controls. Inlet grates inside parking garages are currently required to have much smaller openings than those described herein.

To receive the 25% removal credit, hoods must be used in deep sump catch basins. Hoods also help contain oil spills. MassHighway may install catch basins without hoods provided they are designed, constructed, operated, and maintained in accordance with the Mass Highway Stormwater Handbook.

Install the weep hole above the outlet pipe. Never install the weep hole in the bottom of the catch basin barrel.

Site Constraints

A proponent may not be able to install a deep sump catch basin because of:

- Depth to bedrock;
- High groundwater;
- Presence of utilities; or
- Other site conditions that limit depth of excavation because of stability.

Maintenance

Regular maintenance is essential. Deep sump catch basins remain effective at removing pollutants only if they are cleaned out frequently. One study found that once 50% of the sump volume is filled, the catch basin is not able to retain additional sediments.

Inspect or clean deep sump basins at least four times per year and at the end of the foliage and snow-removal seasons. Sediments must also be removed four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. If handling runoff from land uses with higher potential pollutant loads or discharging runoff near or to a critical area, more frequent cleaning may be necessary.

Clamshell buckets are typically used to remove sediment in Massachusetts. However, vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Always consider the safety of the staff cleaning deep sump catch basins. Cleaning a deep sump catch basin within a road with active traffic or even within a parking lot is dangerous, and a police detail may be necessary to safeguard workers.

Although catch basin debris often contains concentrations of oil and hazardous materials such as petroleum hydrocarbons and metals, MassDEP classifies them as solid waste. Unless there is evidence that they have been contaminated by a spill or other means, MassDEP does not routinely require catch basin cleanings to be tested before disposal. Contaminated catch basin cleanings must be evaluated in accordance with the Hazardous Waste Regulations, 310 CMR 30.000, and handled as hazardous waste.

In the absence of evidence of contamination, catch basin cleanings may be taken to a landfill or other facility permitted by MassDEP to accept solid waste, without any prior approval by MassDEP. However, some landfills require catch basin cleanings to be tested before they are accepted.

With prior MassDEP approval, catch basin cleanings may be used as grading and shaping materials at landfills undergoing closure (see Revised Guidelines for Determining Closure Activities at Inactive Unlined Landfill Sites) or as daily cover at active landfills. MassDEP also encourages the beneficial reuse of catch basin cleanings whenever possible. A Beneficial Reuse Determination is required for such use.

MassDEP regulations prohibit landfills from accepting materials that contain free-draining liquids. One way to remove liquids is to use a hydraulic lift truck during cleaning operations so that the material can be decanted at the site. After loading material from several catch basins into a truck, elevate the truck so that any free-draining liquid can flow back into the structure. If there is no free water in the truck, the material may be deemed to be sufficiently dry. Otherwise the catch basin cleanings must undergo a Paint Filter Liquids Test. Go to www. Mass.gov/dep/recycle/laws/cafacts.doc for information on all of the MassDEP requirements pertaining to the disposal of catch basin cleanings.

Infiltration Basins

Description: Infiltration basins are stormwater runoff impoundments that are constructed over permeable soils. Pretreatment is critical for effective performance of infiltration basins. Runoff from the design storm is stored until it exfiltrates through the soil of the basin floor.

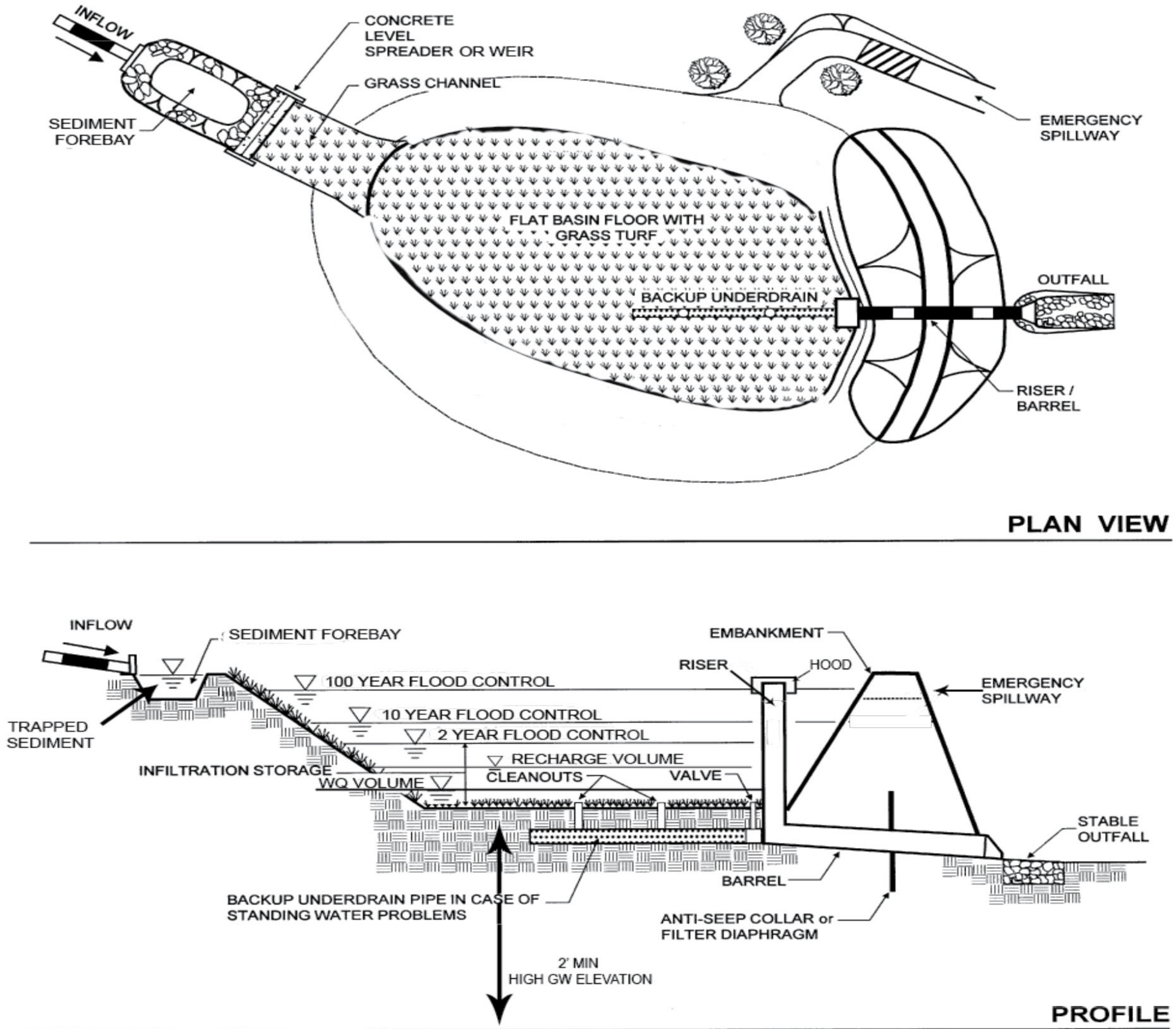
Ability to meet specific standards

Standard	Description
2 - Peak Flow	Can be designed to provide peak flow attenuation.
3 - Recharge	Provides groundwater recharge.
4 - TSS Removal	80% TSS removal, with adequate pretreatment
5 - Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. For some land uses with higher potential pollutant loads, use an oil grit separator, sand filter or equivalent for pretreatment prior to discharge to the infiltration basin. Infiltration must be done in compliance with 314 CMR 5.00
6 - Discharges near or to Critical Areas	Highly recommended, especially for discharges near cold-water fisheries. Requires 44% removal of TSS prior to discharge to infiltration basin
7 - Redevelopment	Typically not an option due to land area constraints

Advantages/Benefits:
- Provides groundwater recharge.
- Reduces local flooding.
- Preserves the natural water balance of the site.
- Can be used for larger sites than infiltration trenches or structures.

Disadvantages/Limitations:
- High failure rates due to improper siting, inadequate pretreatment, poor design and lack of maintenance.
- Restricted to fairly small drainage areas.
- Not appropriate for treating significant loads of sediment and other pollutants.
- Requires frequent maintenance.
- Can serve as a “regional” stormwater treatment facility

Pollutant Removal Efficiencies
- Total Suspended Solids (TSS) 80% with pretreatment
- Total Nitrogen 50% to 60%
- Total Phosphorus 60% to 70%
- Metals (copper, lead, zinc, cadmium) 85% to 90%
- Pathogens (coliform, e coli) 90%



adapted from the Vermont Stormwater Manual

Maintenance

Activity	Frequency
Preventative maintenance	Twice a year
Inspect to ensure proper functioning	After every major storm during first 3 months of operation and twice a year thereafter and when there are discharges through the high outlet orifice.
Mow the buffer area, side slopes, and basin bottom if grassed floor; rake if stone bottom; remove trash and debris; remove grass clippings and accumulated organic matter	Twice a year
Inspect and clean pretreatment devices	Every other month recommended and at least twice a year and after every major storm event.

Special Features: High failure rate without adequate pretreatment and regular maintenance.

LID Alternative: Reduce impervious surfaces. Bioretention areas

Infiltration Basins

The following are variations of the infiltration basin design.

Full Exfiltration Basin Systems

These basin systems are sized to provide storage and exfiltration of the required recharge volume and treatment of the required water quality volume. They also attenuate peak discharges. Designs typically include an emergency overflow channel to discharge runoff volumes in excess of the design storm.

Partial or Off-line Exfiltration Basin Systems

Partial basin systems exfiltrate a portion of the runoff (usually the first flush or the first half inch), with the remaining runoff being directed to other BMPs. Flow splitters or weirs divert flows containing the first flush into the infiltration basin. This design is useful at sites where exfiltration cannot be achieved by downstream detention BMPs because of site condition limitations.

Applicability

The suitability of infiltration basins at a given site is restricted by several factors, including soils, slope, depth to water table, depth to bedrock, the presence of an impermeable layer, contributing watershed area, proximity to wells, surface waters, and foundations. Generally, infiltration basins are suitable at sites with gentle slopes, permeable soils, relatively deep bedrock and groundwater levels, and a contributing watershed area of approximately 2 to 15 acres. Table IB.1 presents the recommended site criteria for infiltration basins.

Pollution prevention and pretreatment are particularly important at sites where infiltration basins are located. A pollution prevention program that separates contaminated and uncontaminated runoff is essential. Uncontaminated runoff can be infiltrated directly, while contaminated runoff must be collected and pretreated using an appropriate combination of BMPs and then rerouted to the infiltration basin. This approach allows uncontaminated stormwater to be infiltrated during and immediately after the storm and permits the infiltration of contaminated stormwater after an appropriate detention time. The Pollution Prevention and Source Control Plan required by Stormwater Standard 4 must take these factors into account. For land uses with higher potential pollutant loads, provide a bypass to divert contaminated stormwater from the infiltration basin in storms larger than the design storm.

Table IB.1 - Site Criteria for Infiltration Basins
1. The contributing drainage area to any individual infiltration basin should be restricted to 15 acres or less.
2. The minimum depth to the seasonal high water table, bedrock, and/or impermeable layer should be 2 ft. from the bottom of the basin.
3. The minimum infiltration rate is 0.17 inches per hour. Infiltration basins must be sized in accordance with the procedures set forth in Volume 3.
4. One soil sample for every 5000 ft. of basin area is recommended, with a minimum of three samples for each infiltration basin. Samples should be taken at the actual location of the proposed infiltration basin so that any localized soil conditions are detected.
5. Infiltration basins should not be used at sites where soil have 30% or greater clay content, or 40% or greater silt clay content.
6. Infiltration basins should not be placed over fill materials.
7. The following setback requirements should apply to infiltration basin installations: • Distance from any slope greater than 15% - Minimum of 50 ft. • Distance from any soil absorption system- Minimum of 50 ft. • Distance from any private well - Minimum of 100 ft., additional setback distance may be required depending on hydrogeological conditions. • Distance from any public groundwater drinking supply wells - Zone I radius, additional setback distance may be required depending on hydrogeological conditions. • Distance from any surface drinking water supply - Zone A • Distance from any surface water of the commonwealth (other than surface water supplies and their tributaries) - Minimum of 50 ft. • Distance from any building foundations including slab foundations without basements - Minimum of 10 ft. downslope and 100 ft. upslope.

Prior to pretreatment, implement the pollution prevention and source control program specified in the Pollution Prevention and Source Control Plan to reduce the concentration of pollutants in the discharge. Program components include careful management of snow and deicing chemicals, fertilizers, herbicides, and pest control. The Plan must prohibit snow disposal in the basin and include measures to prevent runoff of stockpiled snow from entering the basin. Stockpiled snow contains concentrations of sand and deicing chemicals. At industrial sites, keep raw materials and wastes from being exposed to precipitation. Select pretreatment BMPs that remove coarse sediments, oil and grease, and floatable organic and inorganic materials, and soluble pollutants.

Effectiveness

Infiltration basins are highly effective treatment systems that remove many contaminants, including TSS. However, infiltration basins are not intended to remove coarse particulate pollutants. Use a pretreatment device to remove them before they enter the basin. The pollutant removal efficiency of the basin depends on how much runoff is exfiltrated by the basin.

Infiltration basins can be made to control peak discharges by incorporating additional stages in the design. To do this, design the riser outlet structure or weir with multiple orifices, with the lowest orifice set to achieve storage of the full recharge volume required by Standard 3. Design the upper orifices using the same procedures as extended detention basins. The basins can also be designed to achieve exfiltration of storms greater than the required recharge volume. However, in such cases, make sure the soils are permeable enough to allow the basin to exfiltrate the entire volume in a 72-hour period. This may necessitate increasing the size of the floor area of the basin. Generally, it is not economically feasible to provide storage for large infrequent storms, such as the 100-year 24-hour storm.

Planning Considerations

Carefully evaluate sites before planning infiltration basins, including investigating soils, depth to bedrock, and depth to water table. Suitable parent soils should have a minimum infiltration rate of 0.17 inches per hour. Infiltration basis must be sized in accordance with the procedures set forth in Volume 3. The slopes of the contributing drainage area for the infiltration basin must be less than 5%.

Design

Infiltration basins are highly effective treatment and disposal systems when designed properly. The first step before design is providing source control and implementing pollution prevention measures to minimize sediment and other contaminants in runoff discharged to the infiltration basin. Next, consider the appropriate pretreatment BMPs.

Design pretreatment BMPs to pretreat runoff before stormwater reaches the infiltration basin. For Critical Areas, land uses with potentially higher pollutant loads, and soils with rapid infiltration rates (greater than 2.4 inches/hour), pretreatment must remove at least 44% of the TSS. Proponents may comply with this requirement by proposing two pretreatment BMPs capable of removing 25% TSS. However, the issuing authorities (i.e., Conservation Commissions or MassDEP) may require additional pretreatment for other constituents beyond TSS for land uses with higher potential pollutant loads. If the land use has the potential to generate stormwater runoff with high concentrations of oil and grease, treatment by an oil grit separator or equivalent is required before discharge to the infiltration basin.

For discharges from areas other than Critical Areas, land uses with potentially higher pollutant loads, and soils with rapid infiltration rates, MassDEP also requires some TSS pretreatment. Common pretreatment for infiltration basins includes aggressive street sweeping, deep sump catch basins, oil/grit separators, vegetated filter strips, water quality swales, or sediment forebays. Fully stabilize all land surfaces contributing drainage to the infiltration practice after construction is complete to reduce the amount of sediment in runoff that flows to the pretreatment devices.

Always investigate site conditions. Infiltration basins must have a minimum separation from seasonal high groundwater of at least 2 feet. Greater separation is necessary for bedrock. If there is bedrock on the site, conduct an analysis to determine the appropriate vertical separation. The greater the distance from the bottom of the basin media to the seasonal high groundwater elevation, the less likely the basin will fail to drain in the 72-hour period following precipitation.

Determine soil infiltration rates using samples collected at the proposed location of the basin. Take one soil boring or dig one test pit for every 5,000 feet of basin area, with a minimum of three borings for each infiltration basin. Conduct the borings or test pits in the layer where infiltration is proposed. For example, if the A and B horizons are to be removed and the infiltration will be through the C horizon, conduct the borings or test pits through the C horizon. MassDEP requires that borings be at least 20 feet deep or extend to the depth of the limiting layer.

For each bore hole or test pit, evaluate the saturated hydraulic conductivity of the soil, depth to seasonal high groundwater, NRCS soil textural class, NRCS Hydrologic Soil Group, and the presence of fill materials in accordance with Volume 3. Never locate infiltration basins above fill. Never locate infiltration basins in Hydrologic Soil Group "D" soils. The minimum acceptable final soil infiltration rate is 0.17 inches per hour. Design the infiltration basin based on the soil evaluation set forth in Volume 3.

If the proposed basin is determined to be in Hydrologic Soil Group "C" soils, incorporate measures in the design to reduce the potential for clogging, such as providing more pretreatment or greater media depth to provide additional storage. Never use the results of a Title 5 percolation test to estimate a saturated hydraulic conductivity rate, because it tends to greatly overestimate the rate that water will infiltrate into the subsurface.

Estimate seasonal high groundwater based on soil mottles or through direct observation when borings are conducted in April or May, when groundwater levels are likely to be highest. If it is difficult to determine the seasonal high groundwater elevation from the borings or test pits, then use the Frimpter method developed by the USGS (Massachusetts/Rhode Island District Office) to estimate seasonal high groundwater. After estimating the seasonal high groundwater using the Frimpter method, re-examine the bore holes or test pits to determine if there are any field indicators that corroborate the Frimpter method estimate.

Stabilize inlet channels to prevent incoming flow velocities from reaching erosive levels, which can scour the basin floor. Riprap is an excellent inlet stabilizer. Design the riprap so it terminates in a broad apron, thereby distributing runoff more evenly over the basin surface to promote better infiltration.

At a minimum, size the basin to hold the required recharge volume. Determine the required recharge volume using either the static or dynamic methods set forth in Volume 3. Remember that the required storage volume of an infiltration basin is the sum of the quantity of runoff entering the basin from the contributing area and the precipitation directly entering the basin. Include one foot of freeboard above the total of the required recharge volume and the direct precipitation volume to account for design uncertainty. When applying the dynamic method to size the basin, use only the bottom of the basin (i.e., do not include side wall exfiltration) for the effective infiltration area.

Design the infiltration basin to exfiltrate in no less than 72 hours. Consider only the basin floor as the effective infiltration area when determining whether the basin meets this requirement.

Design the basin floor to be as flat as possible to provide uniform ponding and exfiltration of the runoff. Design the basin floor to have as close to a 0% slope as possible. In no case shall the longitudinal slope exceed 1%. Enhanced deposition of sediment in low areas may clog the surface soils, resulting in reduced infiltration and wet areas. Design the side slopes of the basin to be no steeper than 3:1 (horizontal: vertical) to allow for proper vegetative stabilization, easier mowing, easier access, and better public safety.

For basins with a 1% longitudinal slope, it will be necessary to incorporate cells into the design, making sure that the depth of ponded water does not exceed 2 feet, because sloped basin floors cause water to move downhill, thereby decreasing the likelihood of infiltration. Make lateral slopes flat (i.e., 0% slope).

After the basin floor is shaped, place soil additives on the basin floor to amend the soil. The soil additives shall include compost, properly aged to kill any seed stock contained within the compost. Do not put biosolids in the compost. Mix native soils that were excavated from the A or B horizons to create the basin with the compost, and then scarify the native materials and compost into the parent material using a chisel plow or rotary device to a depth of 12 inches. Immediately after constructing the basin, stabilize its bottom and side slopes with a dense turf of water-tolerant grass. Use low-maintenance, rapidly germinating grasses, such as fescues. The selected grasses must be capable of surviving in both wet and dry conditions. Do not use sod, which can prevent roots from directly contacting the underlying soil. During the first two months, inspect the newly established vegetation several times to determine if any remedial actions (e.g., reseeding, irrigating) are necessary.

Never plant trees or shrubs within the basin or on the impounding embankments as they increase the chance of basin failure due to root decay or subsurface disturbance. The root penetration and thatch formation of the turf helps to maintain and may even enhance the original infiltration capacity. Soluble nutrients are taken up by the turf for growth, improving the pollutant removal capacity. Dense turf will impede soil erosion and scouring of the basin floor.

In place of turf, use a basin liner of 6 to 12 inches of fill material, such as coarse sand. Clean and replace this material as needed. Do not use loose stone, riprap, and other irregular materials requiring hand removal of debris and weeds.

Design embankments and spillways to conform to the regulatory guidelines of the state's Office of Dam Safety (302 CMR 10.00). Design infiltration basins to be below surrounding grade to avoid issues related to potential embankment failure. All infiltration basins must have an emergency spillway capable of bypassing runoff from large storms without damage to the impounding structure. Design the emergency spillway to divert the storm associated with brimful conditions without impinging upon the structural integrity of the basin. The brimful condition could be the required recharge volume or a design storm (such as the 2-year, 10-year, or 100-year storm if the basin is designed to provide peak rate attenuation in addition to exfiltration). The storm associated with the brimful conditions should not include the one foot of freeboard required to account for design uncertainty. Design the emergency spillway to shunt water toward a location where the water will not damage wetlands or buildings. A common error is to direct the spillway runoff toward an adjoining property not owned by an applicant. If the emergency spillway is designed to drain the emergency overflow toward an adjoining property, obtain a drainage easement and submit it to the Conservation Commission as part of the Wetlands NOI submission. Place vegetative buffers around the perimeter of the basin for erosion control and additional sediment and nutrient removal.

Monitoring wells: Install one monitoring well in the basin floor per every 5,000 square feet of basin floor. Make sure the monitoring well(s) extend 20 feet beneath the basin floor or to the limiting layer, whichever is higher.

Access: Include access in the basin design. The area at the top of the basin must provide unimpeded vehicular access around the entire basin perimeter. The access area shall be no less than 15 feet.

Inlet Structures: Place inlet structures at one longitudinal end of the basin, to maximize the flow path from the inlet to the overflow outlet. A common error is to design multiple inlet points around the entire basin perimeter.

Outlet structures: Infiltration basins must include an overflow outlet in addition to an emergency spillway. Whether using a single orifice or multiple orifices in the design, at a minimum, set the lowest orifice at or above the required recharge volume.

Drawdown device: Include a device to draw the basin down for maintenance purposes. If the basin includes multiple cells, include a drawdown device for each cell.

Fences: Do not place fences around basins located in Riverfront Areas, as required by 310 CMR 10.58(4)(d)1.d. to avoid impeding wildlife movement. In such cases, consider including a safety bench as part of the design.

Construction

Prior to construction, rope or fence off the area selected for the infiltration basin. Never allow construction equipment to drive across the area intended to serve as the infiltration basin.

Never use infiltration basins as temporary sediment traps for construction activities.

To limit smearing or compacting soils, never construct the basin in winter or when it is raining. Use light earth-moving equipment to excavate the infiltration basin because heavy equipment compacts the soils beneath the basin floor and side slopes and reduces infiltration capacity. Because some compaction of soils is inevitable during construction, add the required soil amendments and deeply till the basin floor with a rotary tiller or a disc harrow to a depth of 12 inches to restore infiltration rates after final grading.

Use proper erosion/sediment control during construction. Immediately following basin construction, stabilize the floor and side slopes of the basin with a dense turf of water-tolerant grass. Use low maintenance, rapidly germinating grasses, such as fescues. Do not sod the basin floor or side slopes. After the basin is completed, keep the basin roped or fenced off while construction proceeds on other parts of the site. Never direct construction period drainage to the infiltration basin. After construction is completed, do not direct runoff into the basin until the bottom and side slopes are fully stabilized.

Maintenance

Infiltration basins are prone to clogging and failure, so it is imperative to develop and implement aggressive maintenance plans and schedules. Installing the required pretreatment BMPs will significantly reduce maintenance requirements for the basin.

The Operation and Maintenance Plan required by Standard 9 must include inspections and preventive maintenance at least twice a year, and after every time drainage discharges through the high outlet orifice. The Plan must require inspecting the pretreatment BMPs in accordance with the minimal requirements specified for those practices and after every major storm event. A major storm event is defined as a storm that is equal to or greater than the 2-year, 24-hour storm (generally 2.9 to 3.6 inches in a 24-hour period, depending in geographic location in Massachusetts).

Once the basin is in use, inspect it after every major storm for the first few months to ensure it is stabilized and functioning properly and if necessary take corrective action. Note how long water remains standing in the basin after a storm; standing water within the basin 48 to 72 hours after a storm indicates that the infiltration capacity may have been overestimated. If the ponding is due to clogging, immediately address the reasons for the clogging (such as upland sediment erosion, excessive compaction of soils, or low spots).
Thereafter, inspect the infiltration basin at least twice per year. Important items to check during the inspection include:

- Signs of differential settlement,
- Cracking,
- Erosion,
- Leakage in the embankments
- Tree growth on the embankments
- Condition of riprap,
- Sediment accumulation and
- The health of the turf.

At least twice a year, mow the buffer area, side slopes, and basin bottom. Remove grass clippings and accumulated organic matter to prevent an impervious organic mat from forming. Remove trash and debris at the same time. Use deep tilling to break up clogged surfaces, and revegetate immediately.

Remove sediment from the basin as necessary, but wait until the floor of the basin is thoroughly dry. Use light equipment to remove the top layer so as to not compact the underlying soil. Deeply till the remaining soil, and revegetate as soon as possible. Inspect and clean pretreatment devices associated with basins at least twice a year, and ideally every other month.

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Sediment Forebays

Description: A sediment forebay is a post-construction practice consisting of an excavated pit, bermed area, or cast structure combined with a weir, designed to slow incoming stormwater runoff and facilitating the gravity separation of suspended solids. This practice is different from a sediment trap used as a construction period BMP.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides no peak flow attenuation
3 - Recharge	Provides no groundwater recharge
4 - TSS Removal	MassDEP requires a sediment forebay as pretreatment before stormwater is discharged to an extended dry detention basin, wet basin, constructed stormwater wetland or infiltration basin. No separate credit is given for the sediment forebay. For example, extended dry detention basins with sediment forebays receive a credit for 50% TSS removal. Wet basins and constructed stormwater wetlands with sediment forebays receive a credit for 80% TSS removal. When they provide pretreatment for other BMPs, sediment forebays receive a 25% TSS removal credit.
5 - Higher Pollutant Loading	Recommended as a pretreatment BMP
6 - Discharges near or to Critical Areas	Recommended as a pretreatment BMP
7 - Redevelopment	Usually not suitable due to land use constraints

Advantages/Benefits:

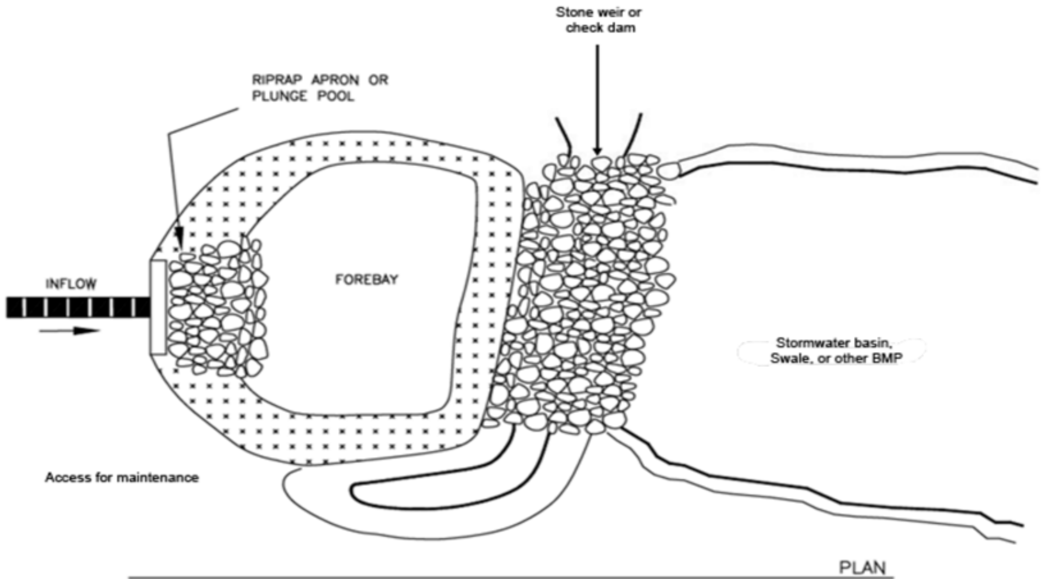
- Provides pretreatment of runoff before delivery to other BMPs.
- Slows velocities of incoming stormwater
- Easily accessed for sediment removal
- Longevity is high with proper maintenance
- Relatively inexpensive compared to other BMPs
- Greater detention time than proprietary separators

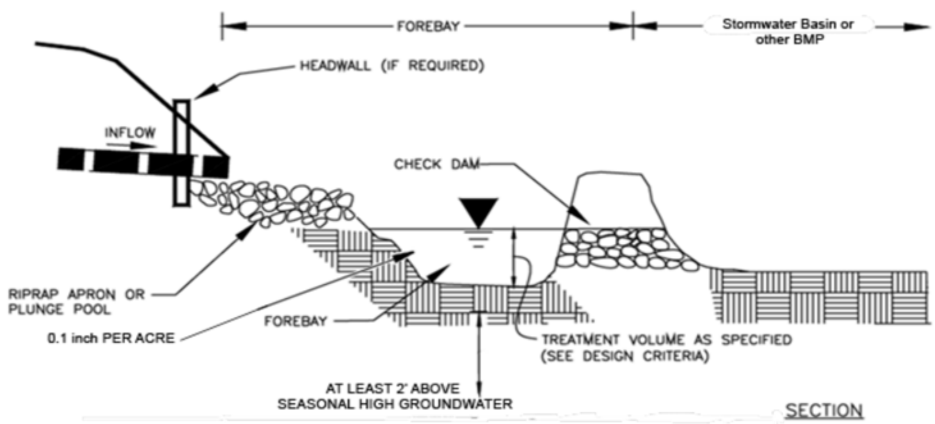
Disadvantages/Limitations:

- Removes only coarse sediment fractions
- No removal of soluble pollutants
- Provides no recharge to groundwater
- No control of the volume of runoff
- Frequent maintenance is essential

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) - 25%
- Nutrients (Nitrogen, phosphorus) - Insufficient data
- Metals (copper, lead, zinc, cadmium) - Insufficient data
- Pathogens (coliform, e coli) - Insufficient data





adapted from the Vermont Stormwater Handbook

Maintenance

Activity	Frequency
Inspect sediment forebays	Monthly
Clean sediment forebays	Four times per year and when sediment depth is between 3 to 6 feet.

Special Features

MassDEP requires a sediment forebay as pretreatment before discharging to a dry extended detention basin, wet basin, constructed stormwater wetland, or infiltration basin.

MassDEP uses the term sediment forebay for BMPs used to pretreat stormwater after construction is complete and the site is stabilized. MassDEP uses the term sediment trap to refer to BMPs used for erosion and sedimentation control during construction. For information on the design and construction of sediment traps used during construction, consult the Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planners, Designers and Municipal Officials.

Sediment Forebays

Design

Sediment forebays are typically on-line units, designed to slow stormwater runoff and settle out sediment.

At a minimum, size the volume of the sediment forebay to hold 0.1-inch/impervious acre to pretreat the water quality volume.

When routing the 2-year and 10-year storms through the sediment forebay, design the forebay to withstand anticipated velocities without scouring.

A typical forebay is excavated below grade with earthen sides and a stone check dam.

Design elevated embankments to meet applicable safety standards.

Stabilize earth slopes and bottoms using grass seed mixes recommended by the NRCS and capable of resisting the anticipated shearing forces associated with velocities to be routed through the forebay. Use only grasses. Using other vegetation will reduce the storage volume in the forebay. Make sure that the selected grasses are able to withstand periodic inundation under water, and drought- tolerant during the summer. MassDEP recommends using a mix of grasses rather than relying upon a single grass species.

Alternatively, the bottom floor may be stabilized with concrete or stone to aid maintenance. Concrete floors or pads, or any hard bottom floor, greatly facilitate the removal of accumulated sediment.

When the bottom floor is vegetated, it may be necessary to remove accumulated sediment by hand, along with re-seeding or re-sodding grasses removed during maintenance.

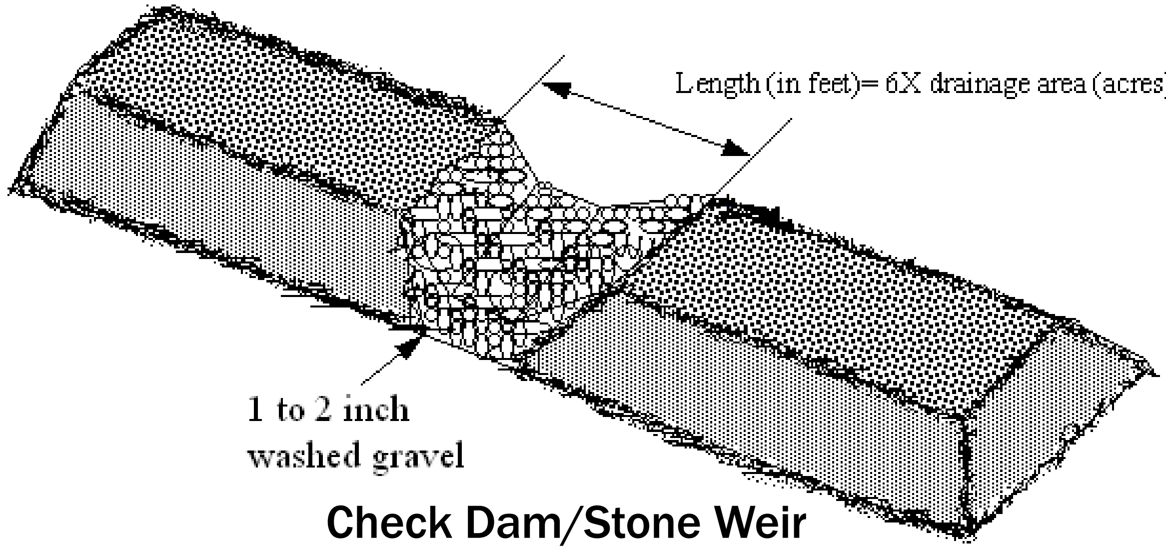
Design sediment forebays to make maintenance accessible and easy. If machinery is required to remove the sediment, carefully incorporate equipment access in the design. Sediment forebays may require excavation so concrete flooring may not always be appropriate.

Include sediment depth markers to simplify inspections. Sediment markers make it easy to determine when the sediment depth is between 3 and 6 feet and needs to be removed. Make the side slopes of sediment forebays no steeper than 3:1. Design the sediment forebay so that the discharge or outflow velocity can control the 2-year peak discharge without scour. Design the channel geometry to prevent erosion from the 2-year peak discharge.

Do not confuse post-construction sediment forebays with the sediment traps used as a construction-period control. Construction-period sediment control traps are sized larger than forebays, because there is a greater amount of suspended solids in construction period runoff. Construction-period sediment traps are sized based on drainage area and not impervious acre. Never use a construction-period sediment trap for post-construction drainage purposes unless it is first brought off-line, thoroughly cleaned (including check dam), and stabilized before being made re-operational.

Refer to the section of this chapter for information on the design of the check dam component of the sediment forebay. Set the minimum elevation of the check dam to hold a volume of 0.1-inch of runoff/impervious acre. Check dam elevations may be uniform or they may contain a weir (e.g., when the top of the check dam is set to the 2-year or 10-year storm, and the bottom of the weir is set to the top of the 0.1-inch/impervious acre volume). When a weir is included in a stone berm, make sure that the weir is able to hold its shape. Fabric or wire may be required.

Unless part of a wet basin, post construction sediment forebays must be designed to dewater between storms. Set the bottom of the forebay at a minimum of 2 feet above seasonal high groundwater, and place pervious material on the bottom floor to facilitate dewatering between storms. For design purposes, use 72 hours to evaluate dewatering, using the storm that produces either the ½ inch or 1-inch of runoff (water quality volume) in a 24-hour period. A stone check dam can act as a filter berm, allowing water to percolate through the check dam. Depending on the head differential, a stone check dam may allow greater dewatering than an earthen berm.



Check Dam/Stone Weir

MassDEP Stormwater Handbook, 1996

Maintenance

Sediments and associated pollutants are removed only when sediment forebays are actually cleaned out, so regular maintenance is essential. Frequently removing accumulated sediments will make it less likely that sediments will be resuspended. At a minimum, inspect sediment forebays monthly and clean them out at least four times per year. Stabilize the floor and sidewalls of the sediment forebay before making it operational, otherwise the practice will discharge excess amounts of suspended sediments. When mowing grasses, keep the grass height no greater than 6 inches. Set mower blades no lower than 3 to 4 inches. Check for signs of rilling and gullying and repair as needed. After removing the sediment, replace any vegetation damaged during the clean-out by either reseeding or re-sodding. When reseeding, incorporate practices such as hydroseeding with a tackifier, blanket, or similar practice to ensure that no scour occurs in the forebay, while the seeds germinate and develop roots.

Subsurface Structures

Description: Subsurface structures are underground systems that capture runoff, and gradually infiltrate it into the groundwater through rock and gravel. There are a number of underground infiltration systems that can be installed to enhance groundwater recharge. The most common types include pre-cast concrete or plastic pits, chambers (manufactured pipes), perforated pipes, and galleys.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	Provides groundwater recharge
4 - TSS Removal	80%
5 - Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. Land uses with the potential to generate runoff with high concentrations of oil and grease require an oil grit separator or equivalent prior to discharge to the infiltration structure. Infiltration must be done in accordance with 314 CMR 5.00.
6 - Discharges near or to Critical Areas	Highly recommended
7 - Redevelopment	Suitable with pretreatment

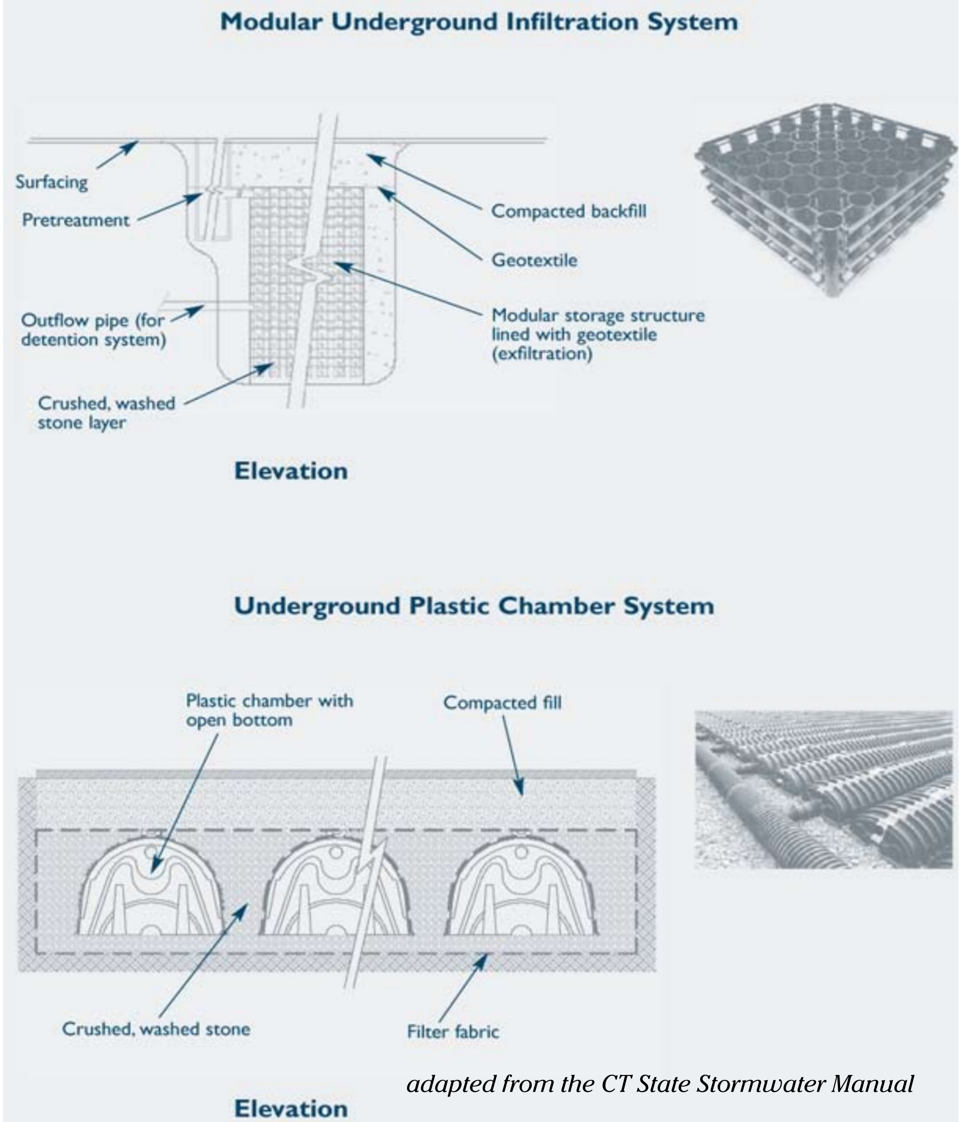
Advantages/Benefits:
- Provides groundwater recharge
- Reduces downstream flooding
- Preserves the natural water balance of the site
- Can remove other pollutants besides TSS
- Can be installed on properties with limited space
- Useful in stormwater retrofit applications

Disadvantages/Limitations:
- Limited data on field performance
- Susceptible to clogging by sediment
- Potential for mosquito breeding due to standing water if system fails

Pollutant Removal Efficiencies

• Total Suspended Solids (TSS)	80%
• Nutrients (Nitrogen, phosphorus)	Insufficient data
• Metals (copper, lead, zinc, cadmium)	Insufficient data
• Pathogens (coliform, e coli)	Insufficient data

Subsurface Structures



adapted from the CT State Stormwater Manual

There are different types of subsurface structures:

Infiltration Pit: A pre-cast concrete or plastic barrel with uniform perforations. The bottom of the pit should be closed with the lowest row of perforations at least 6 inches above the bottom, to serve as a sump. Infiltration pits typically include an observation well. The pits may be placed linearly, so that as the infiltrative surfaces in the first pit clog, the overflow moves to the second pit for exfiltration. Place an outlet near the top of the infiltration pit to accommodate emergency overflows. MassDEP provides recharge credit for storage below the emergency outflow invert. To make an infiltration pit, excavate the pit, wrap fabric around the barrel, place stone in the bottom of the pit, place the barrel in the pit, and then backfill stone around the barrel. Take a boring or dig an observation trench at the site of each proposed pit.

Chambers: These are typically manufactured pipes containing open bottoms and sometimes perforations. The chambers are placed atop a stone bed. Take the same number of borings or observation pits as for infiltration trenches. Do not confuse these systems with underground detention systems (UDS) that use similar chambers. UDS are designed to attenuate peak rates of runoff--not to recharge groundwater.

Perforated Pipes: In this system, pipes containing perforations are placed in a leaching bed, similar to a Title 5 soil absorption system (SAS). The pipes dose the leaching bed. Take the same number of borings or observation pits as for infiltration trenches. Perforated pipes by themselves do not constitute a stormwater recharge system and receive no credit pursuant to Stormwater Standard No. 3. Do not confuse recharge systems that use perforated pipes with perforated pipes installed to lower the water table or divert groundwater flows.

Galleys: Similar to infiltration pits. Some designs consist of concrete perforated rectangular vaults. Others are modular systems usually placed under parking lots. When the galley design consists of a single rectangular perforated vault, conduct one boring or observation trench per galley. When the galleys consist of interlocking modular units, take the same number of borings or observation pits as for infiltration trenches. Do not confuse these galleys with vaults storing water for purposes of underground detention, which do not contain perforations.

Applicability

Subsurface structures are constructed to store stormwater temporarily and let it percolate into the underlying soil. These structures are used for small drainage areas (typically less than 2 acres). They are feasible only where the soil is adequately permeable and the maximum water table and/or bedrock elevation is sufficiently low. They can be used to control the quantity as well as quality of stormwater runoff, if properly designed and constructed. The structures serve as storage chambers for captured stormwater, while the soil matrix provides treatment.

Without adequate pretreatment, subsurface structures are not suitable for stormwater runoff from land uses or activities with the potential for high sediment or pollutant loads. Structural pretreatment BMPs for these systems include, but are not limited to, deep sump catch basins, proprietary separators, and oil/grit separators. They are suitable alternatives to traditional infiltration trenches and basins for space-limited sites. These systems can be installed beneath parking lots and other developed areas provided the systems can be accessed for routine maintenance.

Subsurface systems are highly prone to clogging. Pretreatment is always required unless the runoff is strictly from residential rooftops.

Effectiveness

Performance of subsurface systems varies by manufacturer and system design. Although there are limited field performance data, pollutant removal efficiency is expected to be similar to those of infiltration trenches and basins (i.e., up to 80% of TSS removal). MassDEP awards a TSS removal credit of 80% for systems designed in accordance with the specifications in this handbook.

Planning Considerations

Subsurface structures are excellent groundwater recharge alternatives where space is limited. Because infiltration systems discharge runoff to groundwater, they are inappropriate for use in areas with potentially higher pollutant loads (such as gas stations), unless adequate pretreatment is provided. In that event, oil grit separators, sand filters or equivalent BMPs must be used to remove sediment, floatables and grease prior to discharge to the subsurface structure.

Design

Unlike infiltration basins, widely accepted design standards and procedures for designing subsurface structures are not available. Generally, a subsurface structure is designed to store a "capture volume" of runoff for a specified period of "storage time." The definition of capture volume differs depending on the purpose of the subsurface structure and the stormwater management program being used. Subsurface structures should infiltrate good quality runoff only. Pretreatment prior to infiltration is essential.
The composition, configuration and layout of subsurface structures varies considerably depending on the manufacturer. Follow the design criteria specified by vendors or system manufacturers. Install subsurface structures in areas that are easily accessible for routine and non-routine maintenance.

As with infiltration trenches and basins, install subsurface structures only in soils having suitable infiltration capacities as determined through field testing. Determine the infiltrative capacity of the underlying native soil through the soil evaluation set forth in Volume 3. Never use a standard septic system percolation test to determine soil permeability because this test tends to greatly overestimate the infiltration capacity of soils.

Subsurface structures are typically designed to function off-line. Place a flow bypass structure upgradient of the infiltration structure to convey high flows around the structure during large storms.

Design the subsurface structure so that it drains within 72 hours after the storm event and completely dewaters between storms. Use a minimum draining time of 6 hours to ensure adequate pollutant removal. Design all ports to be mosquito-proof, i.e., to inhibit or reduce the number of mosquitoes able to breed within the BMP.

The minimum acceptable field infiltration rate is 0.17 inches per hour. Subsurface structures must be sized in accordance with the procedures set forth in Volume 3. Manufactured structures must also be sized in accordance with the manufacturers' specifications. Design the system to totally exfiltrate within 72 hours.

Design the subsurface structure for live and dead loads appropriate for their location. Provide measures to dissipate inlet flow velocities and prevent channeling of the stone media. Generally, design the system so that inflow velocities are less than 2 feet per second (fps).
All of these devices must have an appropriate number of observation wells, to monitor the water surface elevation within the well, and to serve as a sampling port.

Each of these different types of structures, with the exception of perforated pipes in leaching fields similar to Title 5 systems, must have entry ports to allow worker access for maintenance, in accordance with OSHA requirements.

Construction

Stabilize the site prior to installing the subsurface structure. Do not allow runoff from any disturbed areas on the site to flow to the structure. Rope off the area where the subsurface structures are to be placed. Accomplish any required excavation with equipment placed just outside of this area. If the size of the area intended for exfiltration is too large to accommodate this approach, use trucks with low-pressure tires to minimize compaction. Do not allow any other vehicles within the area to be excavated. Keep the area above and immediately surrounding the subsurface structure roped off to all construction vehicles until the final top surface is installed (either paving or landscaping). This prevents additional compaction. When installing the final top surface, work from the edges to minimize compaction of the underlying soils.

Before installing the top surface, implement erosion and sediment controls to prevent sheet flow or wind blown sediment from entering the leach field. This includes, but is not limited to, minimizing land disturbances at any one time, placing stockpiles away from the area intended for infiltration, stabilizing any stockpiles through use of vegetation or tarps, and placing sediment fences around the perimeter of the infiltration field.

Provide an access port, man-way, and observation well to enable inspection of water levels within the system. Make the observation well pipe visible at grade (i.e., not buried).

Maintenance

Because subsurface structures are installed underground, they are extremely difficult to maintain. Inspect inlets at least twice a year. Remove any debris that might clog the system. Include mosquito controls in the Operation and Maintenance Plan.

Adapted from:
Connecticut Department of Environmental Conservation. Connecticut Stormwater Quality Manual. 2004.
MassHighway. Storm Water Handbook for Highways and Bridges. May 2004.

USDA United States Department of Agriculture

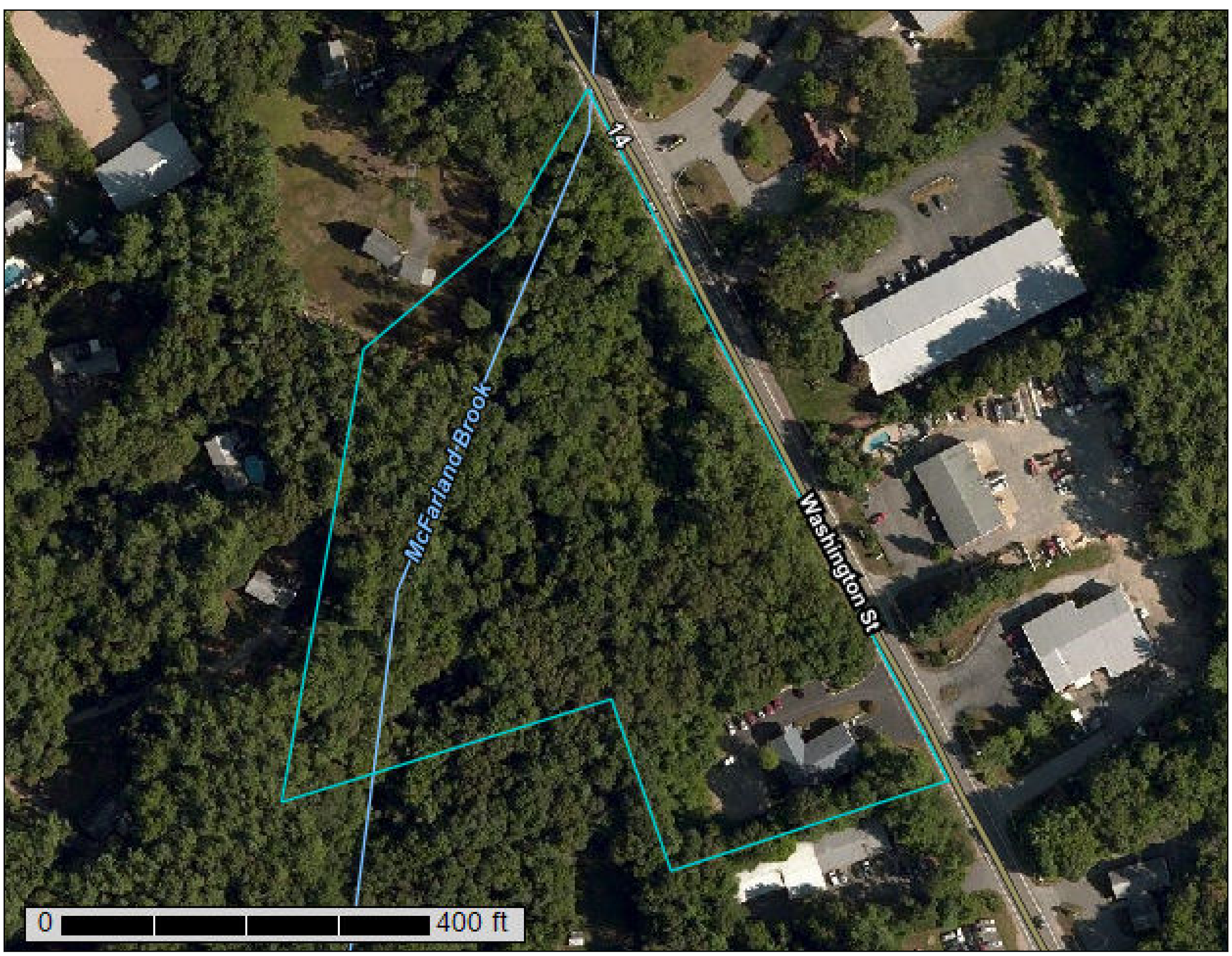
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for

Plymouth County, Massachusetts



December 4, 2019

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

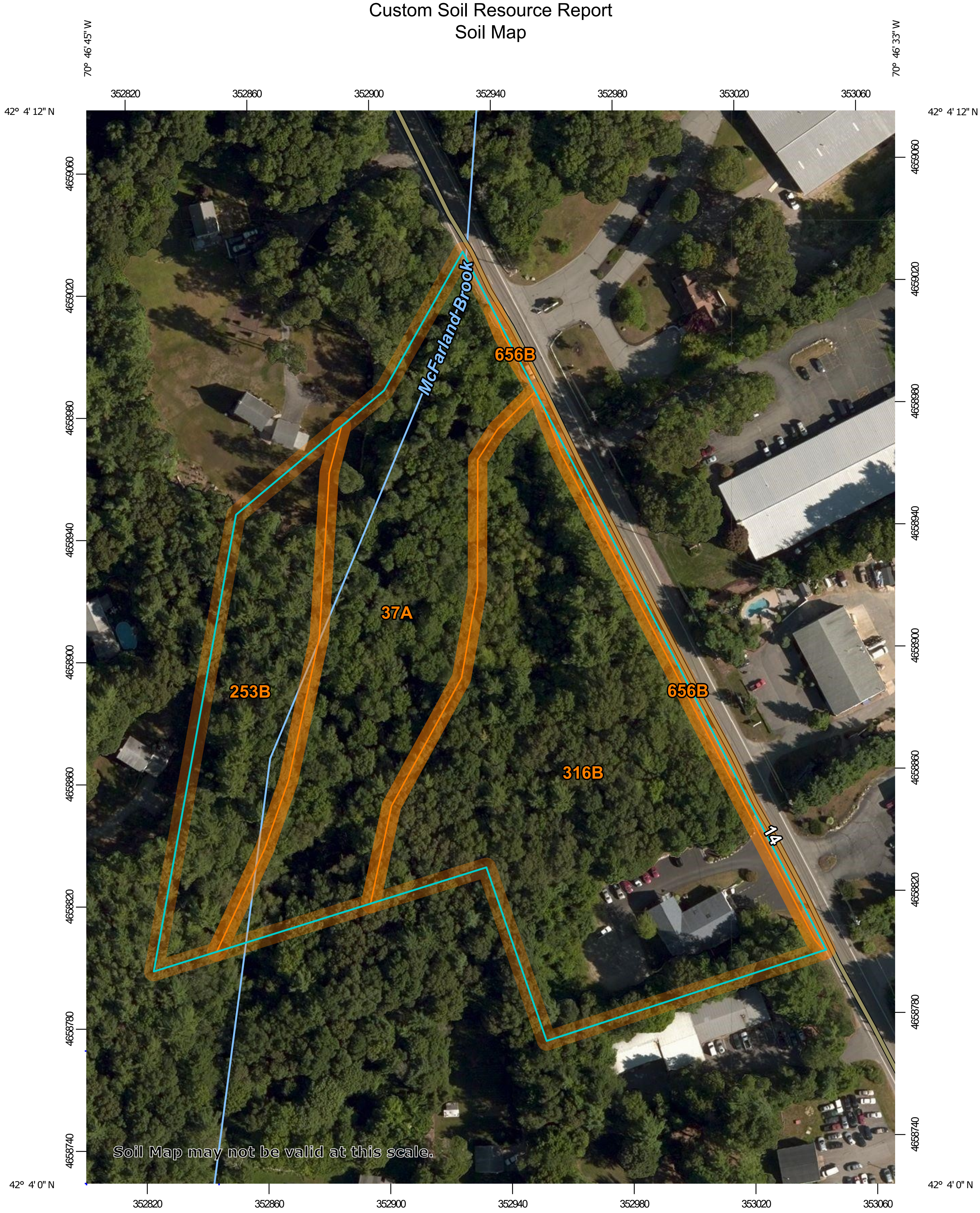
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Soil Map



Map Scale: 1:1,710 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 25, 50, 100, 150

Feet: 0, 50, 100, 200, 300

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

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

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

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

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

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

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

Soil Survey Area: Plymouth County, Massachusetts
Survey Area Data: Version 12, Sep 12, 2019

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

Date(s) aerial images were photographed: Aug 26, 2014—Sep 4, 2014

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
37A	Massasoit - Mashpee complex, 0 to 3 percent slopes	2.3	31.7%
253B	Hinckley loamy sand, 3 to 8 percent slopes	1.2	16.8%
316B	Scituate gravelly sandy loam, 3 to 8 percent slopes, very stony	3.6	50.2%
656B	Udorthents - Urban land complex, 0 to 8 percent slopes	0.1	1.3%
Totals for Area of Interest		**7.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Plymouth County, Massachusetts

37A—Massasoit - Mashpee complex, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: bd1q
Elevation: 0 to 400 feet
Mean annual precipitation: 41 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Massasoit and similar soils: 55 percent
Mashpee and similar soils: 35 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Massasoit

Setting

Landform: Terraces, depressions, drainageways
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Sandy and gravelly glaciofluvial deposits

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
Oa - 1 to 3 inches: highly decomposed plant material
A - 3 to 5 inches: fine sand
Eg1 - 5 to 11 inches: fine sand
Eg2 - 11 to 13 inches: fine sand
Bhs - 13 to 17 inches: fine sand
Bsm - 17 to 23 inches: fine sand
Bs - 23 to 26 inches: fine sand
BC - 26 to 43 inches: fine sand
Cg - 43 to 80 inches: loamy very fine sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: 7 to 20 inches to ortstein
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.01 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Available water storage in profile: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w

Hydrologic Soil Group: D
Hydric soil rating: Yes

Description of Mashpee

Setting

Landform: Depressions, drainageways, terraces
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Sandy and gravelly glaciofluvial deposits

Typical profile

Oe1 - 0 to 2 inches: moderately decomposed plant material
Oe2 - 2 to 4 inches: moderately decomposed plant material
Oa - 4 to 5 inches: highly decomposed plant material
AE - 5 to 7 inches: loamy fine sand
Eg - 7 to 11 inches: fine sand
Bh1 - 11 to 13 inches: fine sand
Bh2 - 13 to 17 inches: fine sand
Bs - 17 to 24 inches: loamy fine sand
C1 - 24 to 39 inches: fine sand
C2 - 39 to 65 inches: fine sand

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (1.42 to 5.95 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Available water storage in profile: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4w
Hydrologic Soil Group: A/D
Hydric soil rating: Yes

Minor Components

Deerfield

Percent of map unit: 5 percent
Landform: Outwash plains, terraces, deltas
Landform position (two-dimensional): Footslope, summit
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Rainberry

Percent of map unit: 3 percent
Landform: Depressions, kettles

Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: Yes

Squamscott

Percent of map unit: 2 percent
Landform: Lake terraces, lake plains
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

253B—Hinckley loamy sand, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2svm8
Elevation: 0 to 1,430 feet
Mean annual precipitation: 36 to 53 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 250 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Hinckley and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Hinckley

Setting

Landform: Outwash terraces, outwash plains, moraines, kame terraces, outwash deltas, kames, eskers
Landform position (two-dimensional): Summit, backslope, footslope, shoulder
Landform position (three-dimensional): Nose slope, side slope, base slope, crest, riser, tread
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave
Parent material: Sandy and gravelly glaciofluvial deposits derived from gneiss and/or granite and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 8 inches: loamy sand
Bw1 - 8 to 11 inches: gravelly loamy sand
Bw2 - 11 to 16 inches: gravelly loamy sand
BC - 16 to 19 inches: very gravelly loamy sand

C - 19 to 65 inches: very gravelly sand

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3s
Hydrologic Soil Group: A
Hydric soil rating: No

Minor Components

Windsor

Percent of map unit: 8 percent
Landform: Kames, eskers, outwash terraces, kame terraces, outwash plains, moraines, outwash deltas
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Nose slope, side slope, base slope, crest, riser, tread
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave
Hydric soil rating: No

Sudbury

Percent of map unit: 5 percent
Landform: Kame terraces, outwash plains, moraines, outwash deltas, outwash terraces
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope, base slope, head slope, tread
Down-slope shape: Concave, linear
Across-slope shape: Linear, concave
Hydric soil rating: No

Agawam

Percent of map unit: 2 percent
Landform: Kame terraces, outwash plains, moraines, outwash deltas, kames, eskers, outwash terraces
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Nose slope, side slope, base slope, crest, tread, riser
Down-slope shape: Linear, convex, concave
Across-slope shape: Convex, linear, concave
Hydric soil rating: No

316B—Scituate gravelly sandy loam, 3 to 8 percent slopes, very stony

Map Unit Setting

National map unit symbol: bczw
Elevation: 10 to 400 feet
Mean annual precipitation: 41 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Farmland of statewide importance

Map Unit Composition

Scituate, very stony, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Scituate, Very Stony

Setting

Landform: Drumlins, ridges
Landform position (two-dimensional): Footslope, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy eolian deposits over sandy lodgment till

Typical profile

Ap - 0 to 11 inches: gravelly sandy loam
Bw1 - 11 to 15 inches: gravelly sandy loam
Bw2 - 15 to 20 inches: sandy loam
BC1 - 20 to 25 inches: gravelly sandy loam
BC2 - 25 to 35 inches: sandy loam
Cd1 - 35 to 46 inches: loamy coarse sand
Cd2 - 46 to 60 inches: loamy coarse sand

Properties and qualities

Slope: 3 to 8 percent
Percent of area covered with surface fragments: 1.5 percent
Depth to restrictive feature: 20 to 35 inches to densic material
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: About 15 to 20 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Low (about 3.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s

Hydrologic Soil Group: C/D
Hydric soil rating: No

Minor Components

Birchwood, very stony

Percent of map unit: 5 percent
Landform: Ground moraines, till plains, drumlins
Landform position (two-dimensional): Summit, footslope
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Norwell, extremely stony

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Landform position (two-dimensional): Footslope, toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Woodbridge, very stony

Percent of map unit: 5 percent
Landform: Drumlins, till plains, hills
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Interfluve
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: No

Montauk, very stony

Percent of map unit: 5 percent
Landform: Till plains, drumlins, ground moraines
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Interfluve
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

656B—Udorthents - Urban land complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: bd08
Elevation: 0 to 390 feet
Mean annual precipitation: 41 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents, loamy, and similar soils: 45 percent
Urban land: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents, Loamy

Setting

Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy human transported material

Typical profile

^A - 0 to 5 inches: loam
^C1 - 5 to 21 inches: gravelly loam
^C2 - 21 to 80 inches: gravelly sandy loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.01 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Udipsamments, wet substratum

Percent of map unit: 5 percent
Landform: Dikes
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear, convex
Across-slope shape: Linear
Hydric soil rating: No

Udorthents, wet substratum

Percent of map unit: 5 percent
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Udipsamments

Percent of map unit: 5 percent
Landform: Dikes
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Tread
Down-slope shape: Linear, convex
Across-slope shape: Linear
Hydric soil rating: No

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Commonwealth of Massachusetts

Pembroke, Massachusetts

Soil Suitability Assessment for On-site Sewage Disposal

Performed by: Kevin Grady
GRADY CONSULTING, L.L.C.
6 Grays Beach Road
Kingston, MA 02364
Phone: (781) 585-2300 Fax: (781) 585-2378

Date: 8/14/07

Witnessed by: Fred Leary

Location Address or Lot #
Washington Street
Assessors Lot F9-24

*Owner's Name *Address & *Telephone #
Edward J. Rorke
25 Eustis Street
Marshfield MA 02050
781 834 5660

New Construction X Repair ___ Title V Inspection ___

Office Review

Published Soil Survey Available: No X Yes ___
Year Published: ___ Publication Scale: ___ Soil Map Unit: ___
Drainage Class: ___ Soil Limitations: ___

Surficial Geology Report Available: No X Yes ___
Year Published: ___ Publication Scale: ___
Geologic Material (Map Unit): ___
Landform: ___

Flood Insurance Rate Map:

Above 500 year flood boundary:	**No** ___	**Yes** X
Within 500 year flood boundary	**No** X	**Yes** ___
Within 100 year flood boundary	**No** X	**Yes** ___

Wetland Area:
National Wetland Inventory Map (map unit): N/A
Wetlands Conservancy Program Map (map unit): ___

Current Water Resource Conditions (USGS): **Month:** July
Range: **Above Normal** ___ **Normal** X **Below Normal** ___

Other References Reviewed: ___

Depth of Naturally Occurring Pervious Material

Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes

If not, what is the depth of naturally occurring pervious material?

Certification

I certify that on April 6, 1999 (date) I have passed the soil evaluator examination approved by the Department of Environmental Protection and that the above analysis was performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017.

Signature: [signature] Date: 8/14/07

TITLE 5 ON-SITE REVIEW

Deep Hole # 1 **Date** 8/14/07 **Time** 9:30 **Weather** sunny 75°
Location(identify on Site Plan)
Land Use Commercial **Slope(%)** 0-2 **Surface Stones** none
Vegetation woods **Landform**

Distances from: Open Water Body – ft. Possible Wet Area 150 ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 50 ft Other

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"-6"	A	Loam	10YR3/3		
6"-22"	B	Sandy Loam	10YR6/6		Friable
22"-48"	C1	Gravelly Sand	2.5Y6/4		20-30% gravel
48"-96"	C2	Gravelly Sandy Loam	2.5Y6/4		20% gravel Tight Removal
96"-152"	C3	Med Sand	2.5Y5/3	none	<2% gravel Loose

Parent Material (geologic) Glacial Till **Depth to Bedrock**
Depth to Groundwater: **Standing Water in Hole:** none **Weeping from Pit Face** none
Estimated Seasonal High Groundwater 12'-8" assumed no water encountered

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:
___ **Depth observed standing in observation hole:** ____ **inches** ____ **Depth to soil mottles:** ____ **inches**
___ **Depth to weeping from side of observation hole:** ____ **inches** ____ **Groundwater adjustment** ____ **ft**
Index Well # ____ **Reading Date** ____ **Index well level** ____ **Adj.factor** ____ **Adj.Groundwater level** ____

PERCOLATION TEST **Date** **Time**

Observation Hole #			**Time at 9"**	9:59	
Depth of Perc	96-114		**Time at 6"**	10:03	
Start Presoak	9:40		**Time (9"-6")**	4 min	
End Presoak	9:55		**Rate Min/Inch**	<2 min/in	

Site Suitability Assessment: **Site Passed** X **Site Failed** ____ **Additional Testing Needed:**
Performed By Kevin Grady **Certification #**
Witnessed By Fred Leary
Comments:

TITLE 5 ON-SITE REVIEW

Deep Hole # 2 **Date** 8/14/07 **Time** 9:30 **Weather** Sunny 75°
Location(identify on Site Plan)
Land Use Commercial **Slope(%)** 0-2 **Surface Stones** none
Vegetation Woods **Landform**

Distances from: Open Water Body – ft. Possible Wet Area 150 ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 30 ft Other

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"- 6"	A	Loam	10YR3/3		
6"-22"	B	Sandy Loam	10YR 6/6		Friable
22"-48"	C	Gravelly Sand	2.5Y 6/4		Friable 20-30% gravel
48"-96"	C2	Gravelly Sandy Loam	2.5Y 6/4		20% gravel Tight Remove
96"-180	C3	Med. Sand	2.5Y 5/3	none	Loose

Parent Material (geologic) Glacial Till **Depth to Bedrock**
Depth to Groundwater: **Standing Water in Hole:** none **Weeping from Pit Face** none
Estimated Seasonal High Groundwater 15'-0" assumed no water encountered

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:
___ **Depth observed standing in observation hole:** ____ **inches** ____ **Depth to soil mottles:** ____ **inches**
___ **Depth to weeping from side of observation hole:** ____ **inches** ____ **Groundwater adjustment** ____ **ft**
Index Well # ____ **Reading Date** ____ **Index well level** ____ **Adj.factor** ____ **Adj.Groundwater level** ____

PERCOLATION TEST **Date** ____ **Time** ____

Observation Hole #			**Time at 9"**	10:43	
Depth of Perc	108"-126"		**Time at 6"**	10:47	
Start Presoak	10:25		**Time (9"-6")**	4min	
End Presoak	10:40		**Rate Min/Inch**	<2min/in	

Site Suitability Assessment: **Site Passed** X **Site Failed** ____ **Additional Testing Needed:**

Performed By Kevin Grady **Certification #**

Witnessed By Fred Leary

Comments:

TITLE 5 ON-SITE REVIEW

Deep Hole # 3 Date 8/14/07 Time 9:30 Weather Sunny 75°

Location(identify on Site Plan) ______

Land Use Commercial Slope(%) 2-4 Surface Stones none

Vegetation Woods Landform ______

Distances from: Open Water Body – ft. Possible Wet Area 120 ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 50 ft Other ______

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"-6"	A	Loam	10YR3/3		
6"-18"	B	Sandy Loam	10YR4/6		Friable
18"-60"	C1	Gravelly Sand	2.5Y6/4		20%-30% gravel
60"-108"	C2	Gravelly Sandy Loam	2.5Y6/4		20% gravel Tight Remove
108" +		Large Rocks	2.5Y5/3	none	<2% gravel Loose

Parent Material (geologic) Glacial Till Depth to Bedrock ______

Depth to Groundwater: Standing Water in Hole: ______ Weeping from Pit Face ______

Estimated Seasonal High Groundwater 9'-0" assumed no water encountered

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:

___ Depth observed standing in observation hole: ____inches ____Depth to soil mottles:______ inches

___ Depth to weeping from side of observation hole:____inches ____ Groundwater adjustment____ft

Index Well #_____ Reading Date_____ Index well level_____ Adj.factor_____ Adj.Groundwater level____

PERCOLATION TEST

Date ______ Time ______

Observation Hole #			Time at 9"		
Depth of Perc			Time at 6"		
Start Presoak			Time (9"-6")		
End Presoak			Rate Min/Inch		

Site Suitability Assessment: Site Passed_____ Site Failed_____ Additional Testing Needed:

Performed By Kevin Grady Certification #______

Witnessed By Fred Leary

Comments:

TITLE 5 ON-SITE REVIEW

Deep Hole # 4 **Date** 8/14/07 **Time** 9:30 **Weather** Sunny 75°
Location(identify on Site Plan)
Land Use Commercial **Slope(%)** 2-5 **Surface Stones** none
Vegetation Woods **Landform**

Distances from: Open Water Body 150 ft. Possible Wet Area 100 ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 100 ft Other

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0-8	A	Loam	10YR3/3		
8-24	B	Sandy Loam	10YR4/6		Friable
24-60	C1	Gravelly Sand	2.5Y6/4		20-30% gravel
60-90	C2	Gravelly Sandy Loam	2.5Y6/4		20% gravel Tight Remove
90-108	C3	Med Sand	2.5Y5/3	none	<2% gravel Loose

Parent Material (geologic) Glacial Till **Depth to Bedrock**
Depth to Groundwater: **Standing Water in Hole:** **Weeping from Pit Face**
Estimated Seasonal High Groundwater 9'-0" assumed no water encountered

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:
___ **Depth observed standing in observation hole:** ___ **inches** ___ **Depth to soil mottles:** ___ **inches**
___ **Depth to weeping from side of observation hole:** ___ **inches** ___ **Groundwater adjustment** ___ **ft**
Index Well # ___ **Reading Date** ___ **Index well level** ___ **Adj.factor** ___ **Adj.Groundwater level** ___

PERCOLATION TEST **Date** ___ **Time** ___

Observation Hole #			**Time at 9"**		
Depth of Perc			**Time at 6"**		
Start Presoak			**Time (9"-6")**		
End Presoak			**Rate Min/Inch**		

Site Suitability Assessment: **Site Passed** ___ **Site Failed** ___ **Additional Testing Needed:**

Performed By ___ **Certification #** ___

Witnessed By ___

Comments:

G C GRADY CONSULTING, L.L.C.
CIVIL ENGINEERS AND LAND SURVEYORS
6 GRAYS BEACH ROAD, KINGSTON, MA 02364
TEL. (781) 585-2300 FAX (781) 585-2378

JOB______
SHEET____ OF____ SCALE:______
CALCULATED BY:______ DATE:____
CHECKED BY:______ DATE:____

MOST PROBABLE HIGH WATER TABLE COMPUTATION

FOR: Washington Street, Pembroke

REFERENCE: USGS Report 80-l205

BASE DATA: Depth to Water 9'

SOIL TYPE: sand/valley **SIMILAR TO:** Duxbury(D4W)#79

FORMULA: Sn = Sc - Sr/Owr * (Owc - Owmax) From Page l8 of Reference

Sc =	9.00	From Original Plan (Depth to Water)
Sr=	4.20	From Fig. 12 (Ref.) vally flat (using 10%)
Owr=	4.04	Highest range of water level within last l2 months *(Jan 1998 Summary)*
Owc	9.03	From U.S.G.S. Web Site August 14, 2007
Owmax =	6.10	From Historical Data Duxbury (D4W)#79

Amount of Adjustment

Sh = 9.0 - (4.2/4.04) * (9.03 - 6.1)

Sh = 9.0 - 3.05 **5.95' below surface**

Commonwealth of Massachusetts

Pembroke , Massachusetts

Soil Suitability Assessment for On-site Sewage Disposal

Performed by: Kevin Grady
GRADY CONSULTING, L.L.C.
71 Evergreen Street, Suite 1
Kingston, MA 02364
Phone: (781) 585-2300 Fax: (781) 585-2378

Date: 8/9/14

Witnessed by: Lisa Collity

Location Address or Lot #: 737 Washington Street

*Owner's Name *Address & *Telephone #: Rose Realty Trust, 55 Redwood Circle, Mashpee MA 02649, 781 826 9511

New Construction ___ Repair ___ Title V Inspection ___

Office Review

Published Soil Survey Available: No X Yes___
Year Published: _________ Publication Scale: _____________ Soil Map Unit: ___________
Drainage Class: _________ Soil Limitations: _________________________

Surficial Geology Report Available: No X Yes ___
Year Published: _________ Publication Scale: ______________
Geologic Material (Map Unit): ______________________
Landform: ______________________

Flood Insurance Rate Map:
Above 500 year flood boundary: **No** ____ **Yes** X
Within 500 year flood boundary **No** X **Yes** ____
Within 100 year flood boundary **No** X **Yes** ____

Wetland Area:
National Wetland Inventory Map (map unit): N/A
Wetlands Conservancy Program Map (map unit): ______________________

Current Water Resource Conditions (USGS): **Month:** August
Range: **Above Normal** X **Normal** ______ **Below Normal** _____

Other References Reviewed: ______________________

Depth of Naturally Occurring Pervious Material

Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes

If not, what is the depth of naturally occurring pervious material?

Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise, and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated on the attached soil evaluation form, are accurate and in accordance with CMR 15.100 through 15.107.

Signature: [signature] Date: 8/9/14

TITLE 5 ON-SITE REVIEW

Deep Hole # 1 **Date** 8/9/19 **Time** 10:00 **Weather** Sunny 80°

Location(identify on Site Plan)

Land Use Commercial **Slope(%)** 0-2 **Surface Stones** none

Vegetation Lawn/weeds **Landform**

Distances from: Open Water Body – ft. Possible Wet Area – ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 20 ft Other

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"-32"	Fill				
32"-36"	A	Loam	3/3		
36"-40	B	LoamySand	10YR5/6		Friable
40-132	C1	LoamySand	2.5Y6/4	none	Friable 5%gravel-few cobbles

Parent Material (geologic) Glacial Till **Depth to Bedrock**

Depth to Groundwater: **Standing Water in Hole:** 130" **Weeping from Pit Face**

Estimated Seasonal High Groundwater 10'-10"

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:

X **Depth observed standing in observation hole:** 130 **inches** ____ **Depth to soil mottles:** ____ **inches**

____ **Depth to weeping from side of observation hole:** ____ **inches** ____ **Groundwater adjustment** ____ **ft**

Index Well # ____ **Reading Date** ____ **Index well level** ____ **Adj.factor** ____ **Adj.Groundwater level** ____

PERCOLATION TEST **Date** **Time**

Observation Hole #			**Time at 9"**	10:00	
Depth of Perc	40-58		**Time at 6"**	10:24	
Start Presoak	9:23		**Time (9"-6")**	~~8min~~ ~~/in~~ 24	
End Presoak	9:38		**Rate Min/Inch**	8min/in	

Site Suitability Assessment: **Site Passed** X **Site Failed** ____ **Additional Testing Needed:**

Performed By Kevin Grady **Certification #**

Witnessed By Lisa Collins-[illegible]

Comments:

TITLE 5 ON-SITE REVIEW

Deep Hole # 2 Date 8/9/19 Time 10:15 Weather Sunny 80°
Location(identify on Site Plan)
Land Use Commercial Slope(%) 0-2 Surface Stones none
Vegetation Lawn/Woods Landform

Distances from: Open Water Body – ft. Possible Wet Area – ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 30 ft Other

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"-24"	Fill				
24-30	A	Loam	10YR3/3		
30-84	C1	Med Sand	2.5Y6/4		0% gravel loose
84-120	C2	Med Sand	2.5Y6/2	none	5% gravel loose

Parent Material (geologic) Glacial Till Depth to Bedrock
Depth to Groundwater: Standing Water in Hole: none Weeping from Pit Face none
Estimated Seasonal High Groundwater 10'-0" assumed no water encountered

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:
___ Depth observed standing in observation hole: ____inches ____Depth to soil mottles:______ inches
___ Depth to weeping from side of observation hole:____inches ____ Groundwater adjustment____ft
Index Well #_____ Reading Date_____ Index well level_____ Adj.factor_____ Adj.Groundwater level____

PERCOLATION TEST Date Time

Observation Hole #			Time at 9"	10:21	
Depth of Perc	30-48		Time at 6"	10:25	
Start Presoak	10:00		Time (9"-6")	4 min	
End Presoak	10:15		Rate Min/Inch	<2 min/in	

Site Suitability Assessment: Site Passed X Site Failed_____ Additional Testing Needed:
Performed By Kevin Grady Certification #
Witnessed By Lisa Cullity
Comments:

TITLE 5 ON-SITE REVIEW

Deep Hole # 3 Date 8/9/19 Time 10:00 Weather sunny 80°

Location(identify on Site Plan)________

Land Use Commercial Slope(%) 0-2 Surface Stones stonewall

Vegetation Woods Landform________

Distances from: Open Water Body – ft. Possible Wet Area – ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 15 ft Other________

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency, %Gravel
0-24	Fill	Fill ~~Loam~~			
24-30	A	A Loam	10YR3/3		
30-40	B	B Loamy Sand	10YR5/6		Friable
40-72	C	Loamy Sand	2.5Y4/4	none	few large Boulders @ Bottom well drained unable to Remove

Parent Material (geologic) Glacial Till Depth to Bedrock________

Depth to Groundwater: Standing Water in Hole: none Weeping from Pit Face none

Estimated Seasonal High Groundwater 6'-0" assumed no water

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:

___ Depth observed standing in observation hole: ____inches ____Depth to soil mottles:______ inches

___ Depth to weeping from side of observation hole:____inches ____ Groundwater adjustment____ft

Index Well #_____ Reading Date_____ Index well level_____ Adj.factor_____ Adj.Groundwater level____

PERCOLATION TEST Date________ Time________

Observation Hole # ______ ______ Time at 9" ______ ______

Depth of Perc ______ ______ Time at 6" ______ ______

Start Presoak ______ ______ Time (9"-6") ______ ______

End Presoak ______ ______ Rate Min/Inch ______ ______

Site Suitability Assessment: Site Passed_____ Site Failed_____ Additional Testing Needed:

Performed By________ Certification #________

Witnessed By________

Comments:

TITLE 5 ON-SITE REVIEW

Deep Hole # 4 **Date** 8/9/19 **Time** 11:00 **Weather** Sunny 80

Location(identify on Site Plan)________

Land Use commercial **Slope(%)** 0-2 **Surface Stones** stonewall

Vegetation woods **Landform**________

Distances from: Open Water Body – ft. Possible Wet Area – ft. Drinking Water Well – ft.

Drainageway – ft. Propertyline 30 ft Other________

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"-6"	A	Loam	10YR3/3		
6"-30"	B	Loamy Sand	10YR5/6		Friable
30"-120"	C	Loamy Sand	2.5Y6/4	none	5%gravel Friable

Parent Material (geologic) Glacial Till **Depth to Bedrock**________

Depth to Groundwater: **Standing Water in Hole:**____ **Weeping from Pit Face**____

Estimated Seasonal High Groundwater 10'-0" assumed no water

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:

___ **Depth observed standing in observation hole:** ____**inches** ____**Depth to soil mottles:**____ **inches**

___ **Depth to weeping from side of observation hole:**____**inches** ____ **Groundwater adjustment**____**ft**

Index Well #____ **Reading Date**____ **Index well level**____ **Adj.factor**____ **Adj.Groundwater level**____

PERCOLATION TEST

Date________ **Time**________

Observation Hole # ____ ____ **Time at 9"** ____ ____

Depth of Perc ____ ____ **Time at 6"** ____ ____

Start Presoak ____ ____ **Time (9"-6")** ____ ____

End Presoak ____ ____ **Rate Min/Inch** ____ ____

Site Suitability Assessment: **Site Passed**____ **Site Failed**____ **Additional Testing Needed:**

Performed By________ **Certification #**________

Witnessed By________

Comments: