"SCHOOLHOUSE COMMONS"
20 UNIT APARTMENT COMPLEX
172 WOBURN STREET, READING
DRAINAGE REPORT

This drainage report is intended to accompany a Site Development plan set prepared by Sullivan Engineering Group, LLC. The owner is seeking to redevelop the existing building/site as a 40B project to accommodate 20 residential apartment units. The existing site has roof drains, drain manholes, and catchbasins that all discharge to the existing 30 inch RCP Drain just off the easterly side of the property. There is no evidence of any existing on-site drainage infiltration system. In reviewing this project from a drainage perspective, the existing building footprint will remain almost the same (there is a small increase in building footprint at the rear of the building) and many of the abutters expressed concerns with drainage since the majority of the site drainage discharges overland to a catchbasin at the southeasterly portion of the property. An attempt has been made to decrease stormwater runoff exiting the site overland and via the closed drainage system. The proposed drainage mitigation for this site will consist of a drainage infiltration field to collect the entire roofed area of the building, 10 parking spaces being constructed of pervious pavers, removal of some onsite pavement for landscaping purposes, and construction of a rain garden upgradient of the existing catchbasin at the southeasterly portion of the site. The combination of these items will reduce offsite runoff to the abutting properties and to the existing 30 RCP drain.

Soil testing was conducted onsite on 6/3/2016 in the area of the proposed infiltration field and witnessed by the Town of Reading Engineering Division. The soil was found to be highly suitable for drainage infiltration (med-coarse sand). The groundwater table was found to be high (36" below grade) based on soil mottling observed. As such, the infiltration field proposed is a low profile system which is sited 1 foot above the seasonal high groundwater table. Since the infiltration field receives only "clean" runoff from the roof the 1 foot separation is an acceptable design, even though a 2 foot separation is preferred. In this case a 2 foot separation is not feasible based on existing site grades. The infiltration field will consist of Cultec Contactor 100HD units (45 units total) bedded on 6 inches of crushed stone. The crushed stone bedding was not factored into the HydroCAD sizing model. The entire roof area of the building (8,310 s.f.) will be conveyed via roof drains to a series of drain manholes and ultimately to the infiltration field. The HDPE piping connecting the drainage manholes are sized for the 10 year storm event. There is an Outlet Control drainage manhole from the infiltration field that will discharge via a 6" HPDE drain to the existing catchbasin at the southeasterly corner of the site. The entire 2 year storm event and the majority of the 10 year storm event is infiltrated within the infiltration field area. A rain garden has been added to the rear of the property just upgradient of the existing catchbasin. The rain garden will have a rip-rap channel on the upgradient side to channel and treat stormwater runoff from the parking lot. The rain garden was NOT modeled in the drainage analysis but will provide stormwater pre-treatment and some storage prior to discharge to the existing catchbasin. Presently there is no pretreatment or storage prior to stormwater entering the catchbasin so this is an improvement. Additionally, by adding the infiltration field for this project a large amount of stormwater is being removed from the 30" RCP drain so the overall drainage loading for this system will be reduced

Attached is the HydroCAD report showing the drainage infiltration field sizing for the 2, 10, and 100 year storm event.

Very Truly Yours,

Jack Sullivan, PE

COMMONWEALTH OF MASSACHUSETTS
JOHN D.
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CIVIL
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12-9-16

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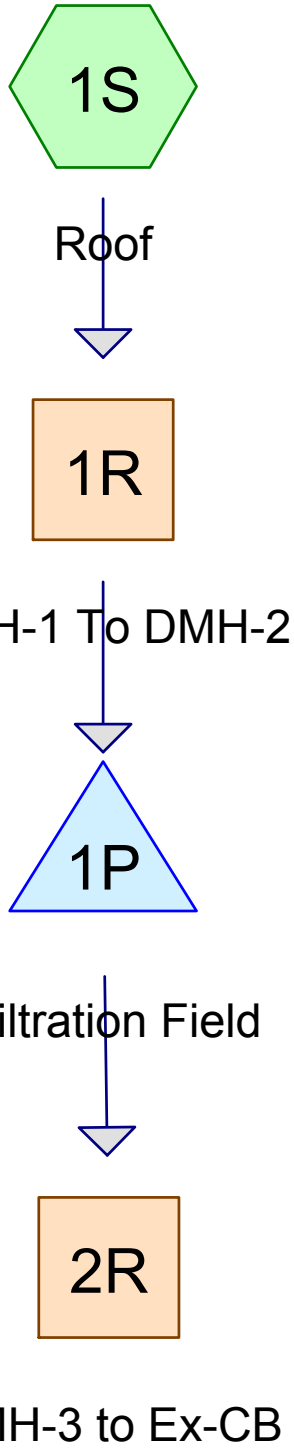
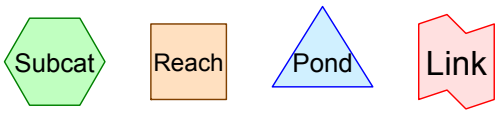




Drainage Diagram for 172 Woburn Street
Prepared by {enter your company name here} 12/12/2016
HydroCAD® 7.00 s/n 001433 © 1986-2003 Applied Microcomputer Systems

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Roof Runoff Area=8,310 sf Runoff Depth=2.68"
Tc=6.0 min CN=98 Runoff=0.56 cfs 1,857 cf

Reach 1R: DMH-1 To DMH-2 Peak Depth=0.36' Max Vel=2.9 fps Inflow=0.56 cfs 1,857 cf
D=8.0" n=0.011 L=53.0' S=0.0049 '/' Capacity=1.00 cfs Outflow=0.55 cfs 1,856 cf

Reach 2R: DMH-3 to Ex-CB Peak Depth=0.00' Max Vel=0.0 fps Inflow=0.00 cfs 0 cf
D=6.0" n=0.011 L=36.0' S=0.0286 '/' Capacity=1.12 cfs Outflow=0.00 cfs 0 cf

Pond 1P: Infiltration Field Peak Elev=105.12' Storage=338 cf Inflow=0.55 cfs 1,856 cf
Discarded=0.24 cfs 1,849 cf Primary=0.00 cfs 0 cf Outflow=0.24 cfs 1,849 cf

Total Runoff Area = 8,310 sf Runoff Volume = 1,857 cf Average Runoff Depth = 2.68"

Subcatchment 1S: Roof

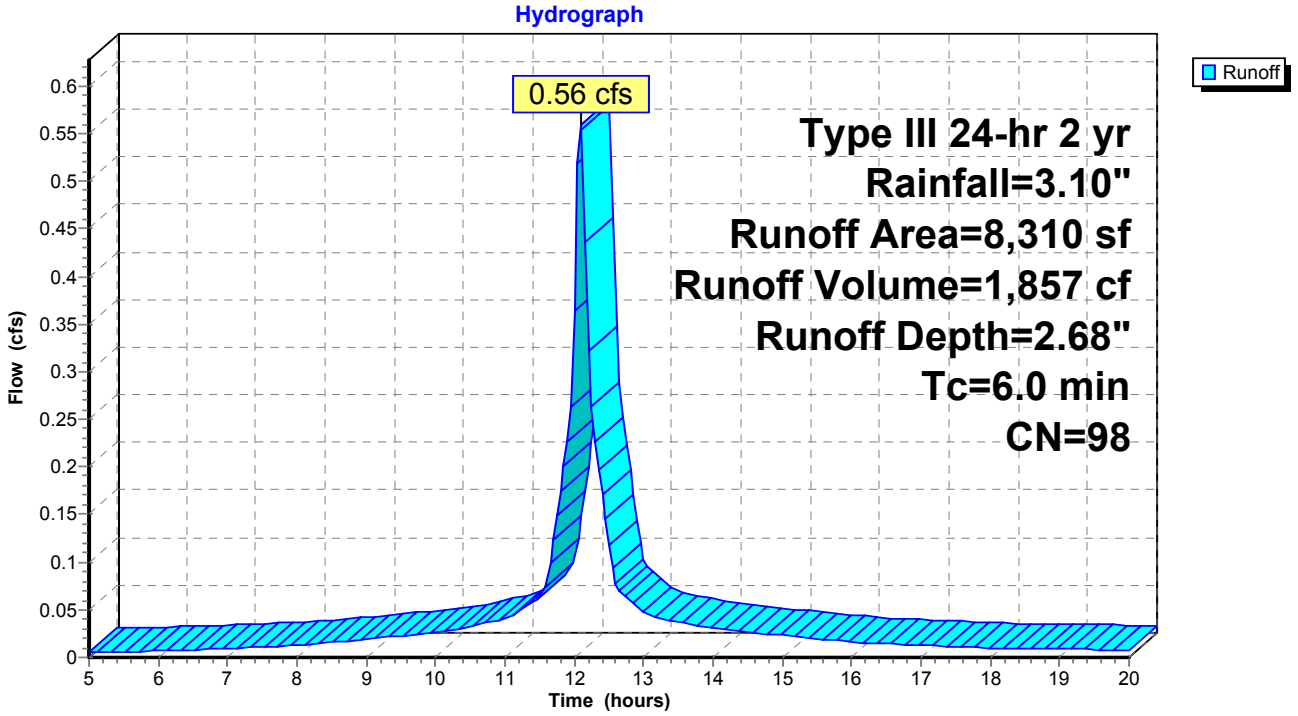
Runoff = 0.56 cfs @ 12.09 hrs, Volume= 1,857 cf, Depth= 2.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2 yr Rainfall=3.10"

Area (sf)	CN	Description
8,310	98	Ex. Roof Area of Building + Rear Addition

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

Subcatchment 1S: Roof



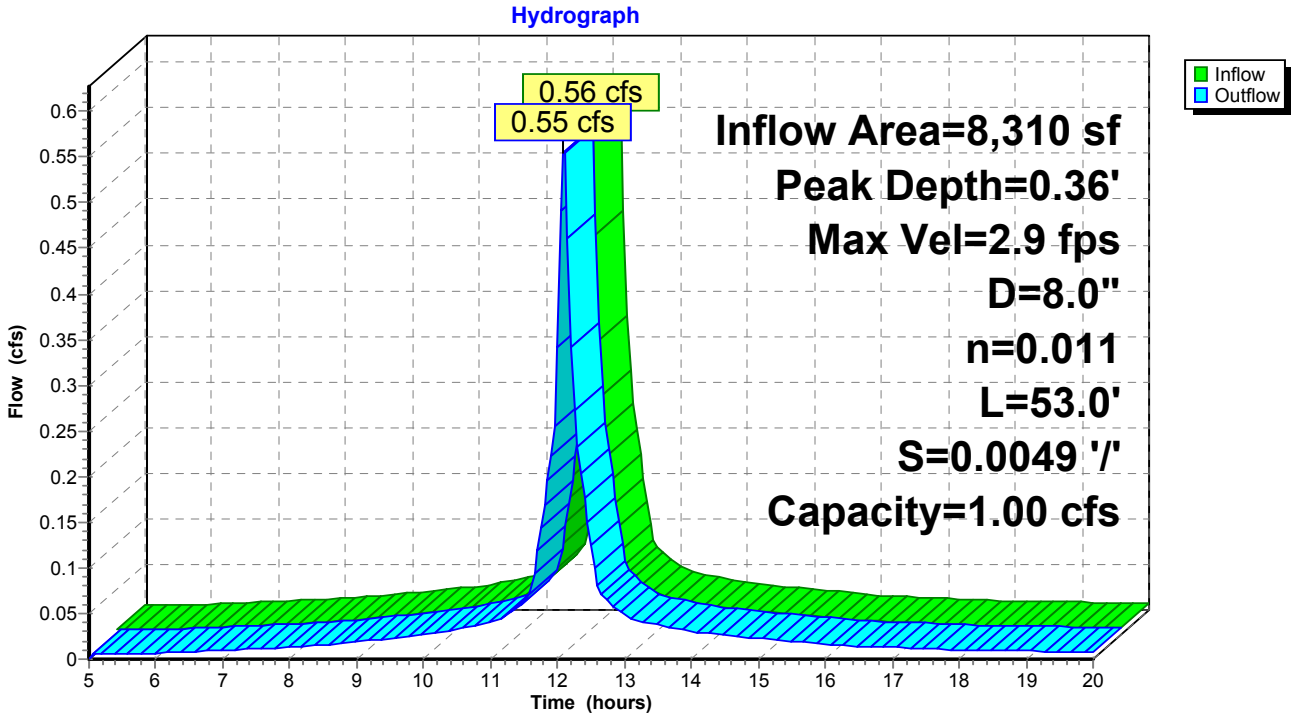
Reach 1R: DMH-1 To DMH-2

Inflow Area = 8,310 sf, Inflow Depth = 2.68" for 2 yr event
Inflow = 0.56 cfs @ 12.09 hrs, Volume= 1,857 cf
Outflow = 0.55 cfs @ 12.10 hrs, Volume= 1,856 cf, Atten= 1%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.9 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.2 fps, Avg. Travel Time= 0.8 min

Peak Depth= 0.36' @ 12.09 hrs
Capacity at bank full= 1.00 cfs
Inlet Invert= 105.16', Outlet Invert= 104.90'
8.0" Diameter Pipe n= 0.011 Length= 53.0' Slope= 0.0049 '/'

Reach 1R: DMH-1 To DMH-2



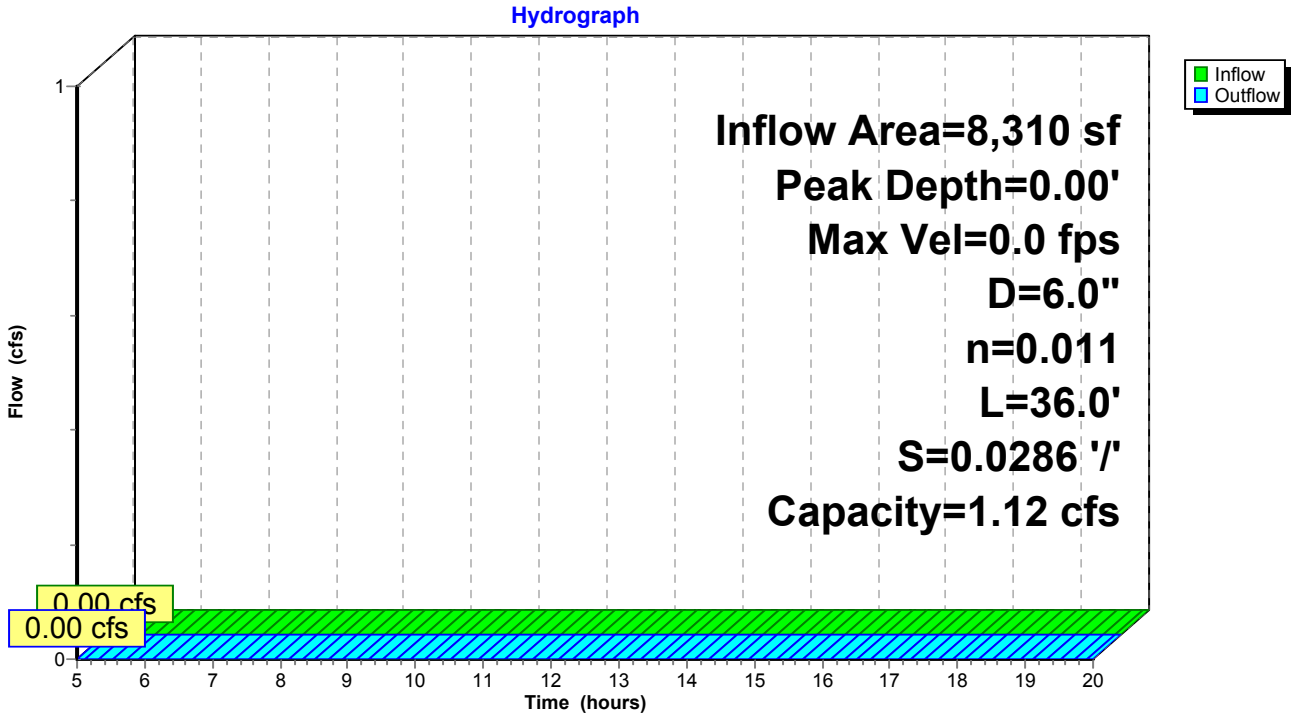
Reach 2R: DMH-3 to Ex-CB

Inflow Area = 8,310 sf, Inflow Depth = 0.00" for 2 yr event
Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0 cf
Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.0 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 0.0 fps, Avg. Travel Time= 0.0 min

Peak Depth= 0.00' @ 5.00 hrs
Capacity at bank full= 1.12 cfs
Inlet Invert= 105.25', Outlet Invert= 104.22'
6.0" Diameter Pipe n= 0.011 Length= 36.0' Slope= 0.0286 '/'

Reach 2R: DMH-3 to Ex-CB



Pond 1P: Infiltration Field

Soil Type is Sand...Rawls Rate of 8.27 in/hr used for exfiltration rate (0.011486 ft/min)

Inflow Area =	8,310 sf,	Inflow Depth =	2.68"	for 2 yr event	
Inflow =	0.55 cfs @	12.10 hrs,	Volume=	1,856 cf	
Outflow =	0.24 cfs @	12.10 hrs,	Volume=	1,849 cf,	Atten= 57%, Lag= 0.3 min
Discarded =	0.24 cfs @	12.10 hrs,	Volume=	1,849 cf	
Primary =	0.00 cfs @	5.00 hrs,	Volume=	0 cf	

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 105.12' @ 12.30 hrs Surf.Area= 1,233 sf Storage= 338 cf
Plug-Flow detention time= 15.8 min calculated for 1,843 cf (99% of inflow)
Center-of-Mass det. time= 14.2 min (753.9 - 739.7)

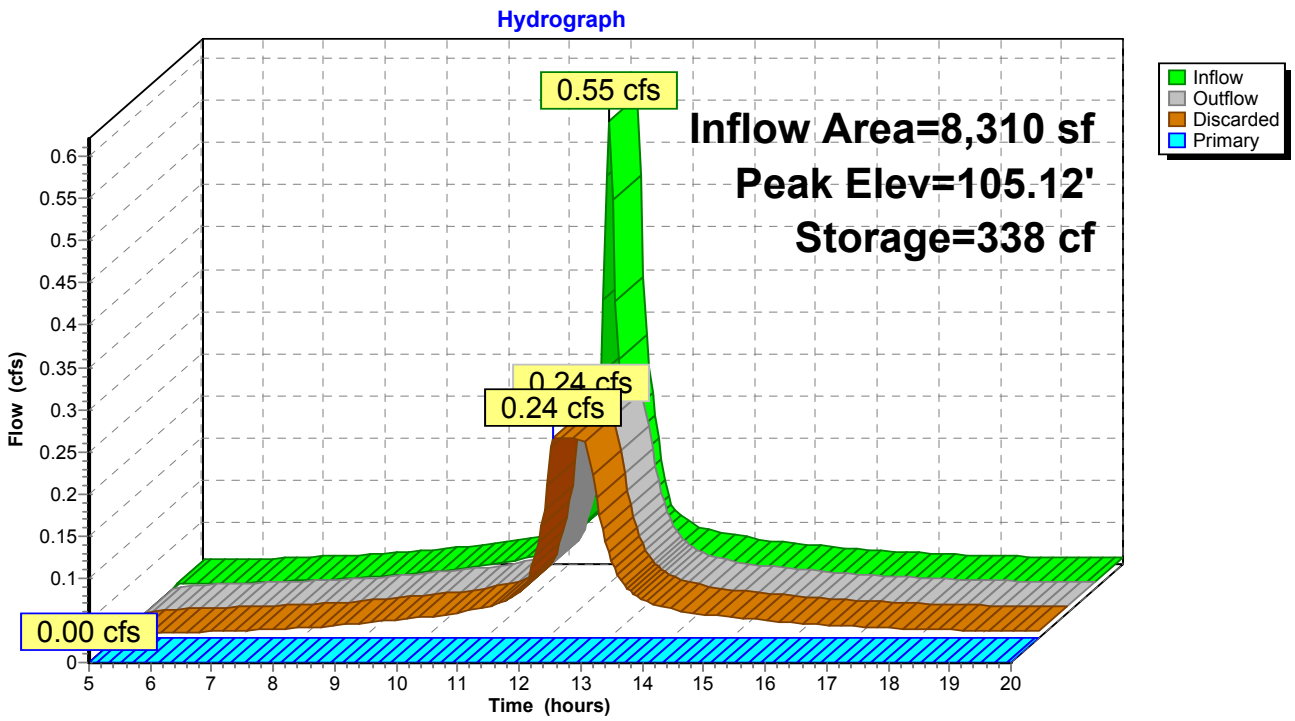
#	Invert	Avail.Storage	Storage Description
1	104.80'	8,843 cf	**18.00'W x 68.50'L x 18.50'H Prismatoid**
			22,811 cf Overall - 703 cf Embedded = 22,107 cf x 40.0% Voids
2	104.80'	703 cf	**36.0"W x 12.5"H x 7.50'L Parabolic Arch** x 45 Inside #1
		9,546 cf	Total Available Storage

#	Routing	Invert	Outlet Devices
1	Discarded	0.00'	**0.011486 fpm Exfiltration over entire Surface area**
2	Primary	105.25'	**6.0" Horiz. Orifice/Grate** Limited to weir flow C= 0.600

Discarded OutFlow Max=0.24 cfs @ 12.10 hrs HW=105.03' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.24 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=104.80' (Free Discharge)
└─**2=Orifice/Grate** (Controls 0.00 cfs)

Pond 1P: Infiltration Field



Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Roof Runoff Area=8,310 sf Runoff Depth=4.24"
Tc=6.0 min CN=98 Runoff=0.87 cfs 2,934 cf

Reach 1R: DMH-1 To DMH-2 Peak Depth=0.48' Max Vel=3.2 fps Inflow=0.87 cfs 2,934 cf
D=8.0" n=0.011 L=53.0' S=0.0049 '/' Capacity=1.00 cfs Outflow=0.87 cfs 2,932 cf

Reach 2R: DMH-3 to Ex-CB Peak Depth=0.14' Max Vel=4.3 fps Inflow=0.20 cfs 204 cf
D=6.0" n=0.011 L=36.0' S=0.0286 '/' Capacity=1.12 cfs Outflow=0.19 cfs 204 cf

Pond 1P: Infiltration Field Peak Elev=105.37' Storage=571 cf Inflow=0.87 cfs 2,932 cf
Discarded=0.24 cfs 2,717 cf Primary=0.20 cfs 204 cf Outflow=0.43 cfs 2,922 cf

Total Runoff Area = 8,310 sf Runoff Volume = 2,934 cf Average Runoff Depth = 4.24"

Subcatchment 1S: Roof

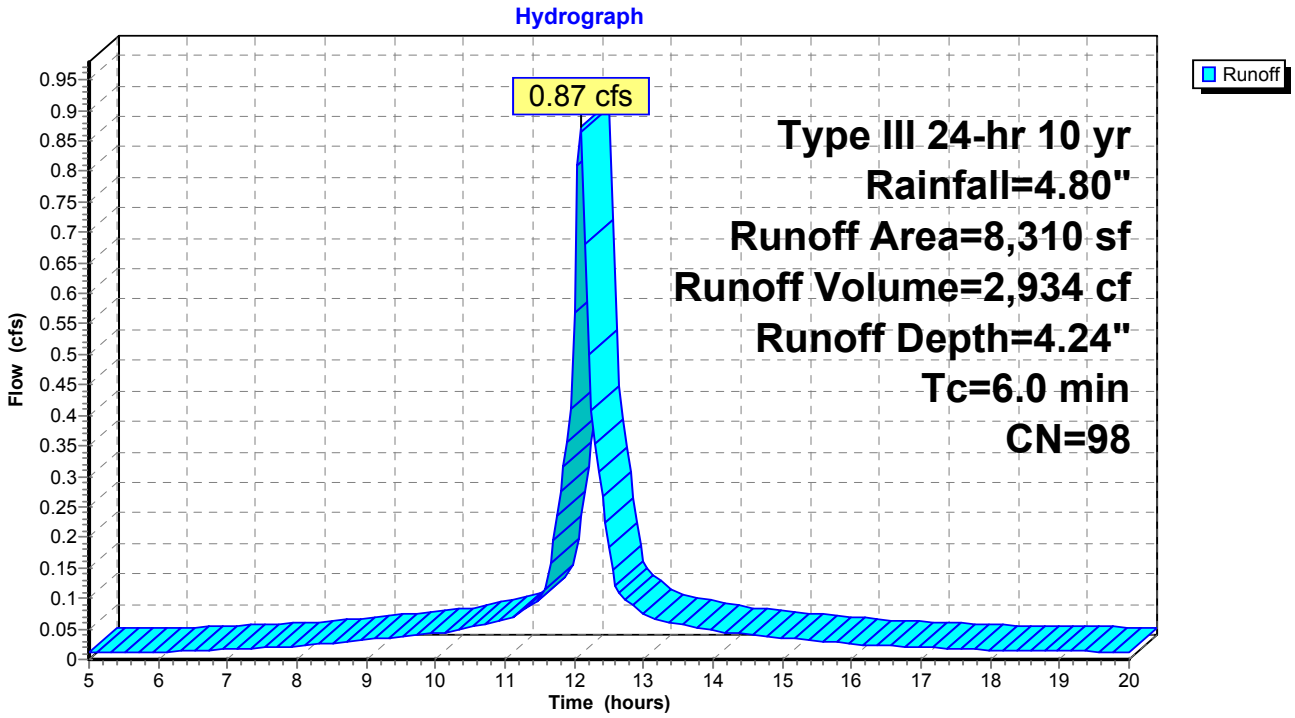
Runoff = 0.87 cfs @ 12.09 hrs, Volume= 2,934 cf, Depth= 4.24"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 yr Rainfall=4.80"

Area (sf)	CN	Description
8,310	98	Ex. Roof Area of Building + Rear Addition

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

Subcatchment 1S: Roof



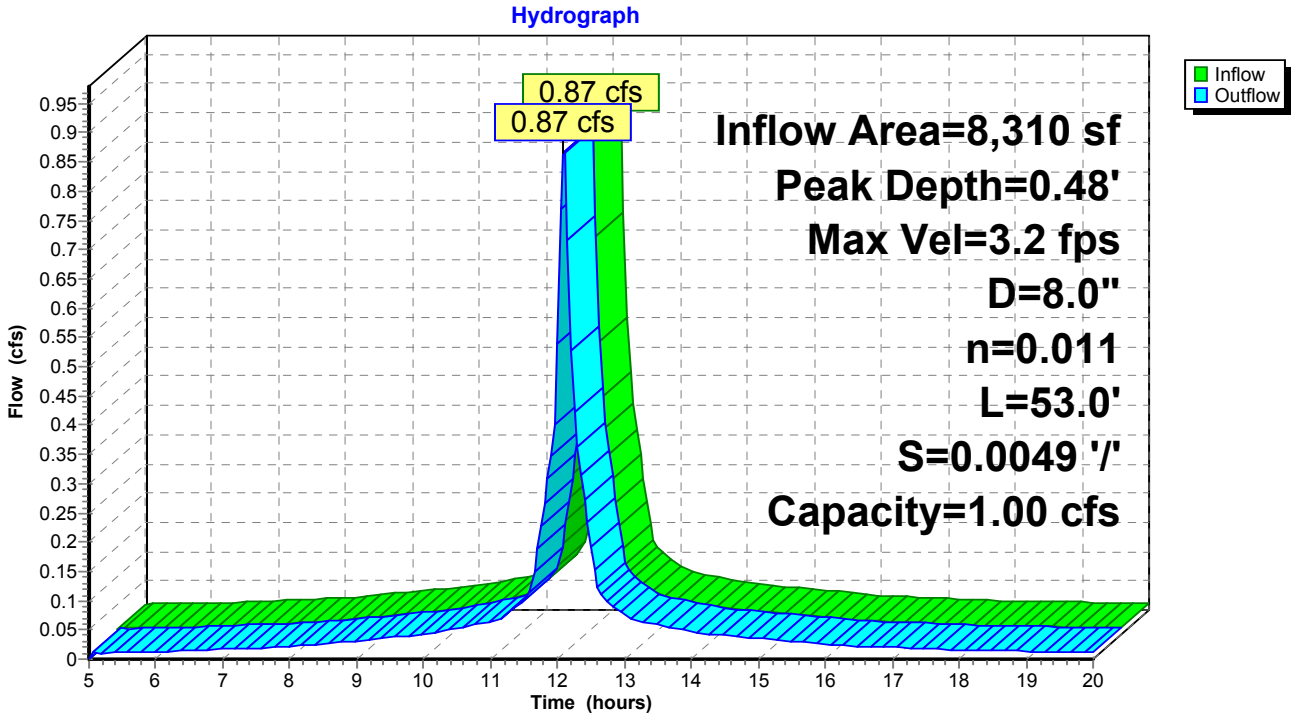
Reach 1R: DMH-1 To DMH-2

Inflow Area = 8,310 sf, Inflow Depth = 4.24" for 10 yr event
Inflow = 0.87 cfs @ 12.09 hrs, Volume= 2,934 cf
Outflow = 0.87 cfs @ 12.09 hrs, Volume= 2,932 cf, Atten= 1%, Lag= 0.5 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.3 fps, Avg. Travel Time= 0.7 min

Peak Depth= 0.48' @ 12.09 hrs
Capacity at bank full= 1.00 cfs
Inlet Invert= 105.16', Outlet Invert= 104.90'
8.0" Diameter Pipe n= 0.011 Length= 53.0' Slope= 0.0049 '/'

Reach 1R: DMH-1 To DMH-2



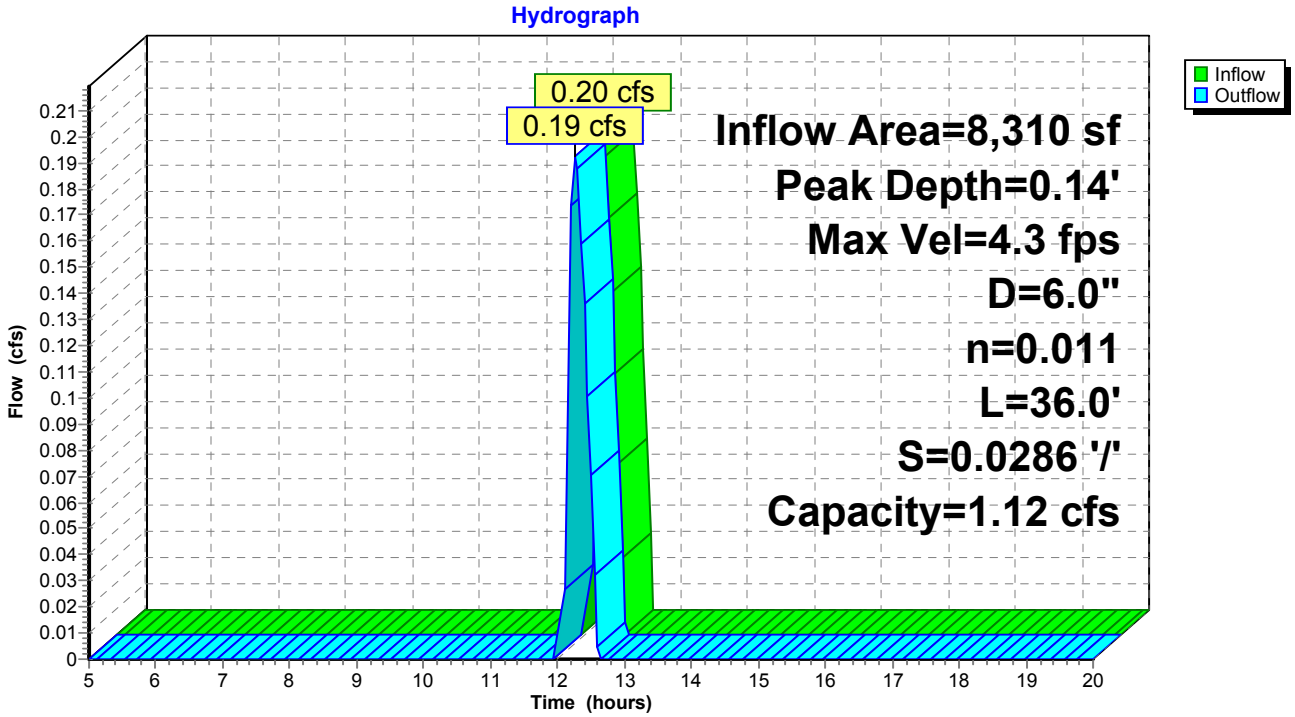
Reach 2R: DMH-3 to Ex-CB

Inflow Area = 8,310 sf, Inflow Depth = 0.29" for 10 yr event
Inflow = 0.20 cfs @ 12.26 hrs, Volume= 204 cf
Outflow = 0.19 cfs @ 12.27 hrs, Volume= 204 cf, Atten= 2%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.3 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 3.4 fps, Avg. Travel Time= 0.2 min

Peak Depth= 0.14' @ 12.26 hrs
Capacity at bank full= 1.12 cfs
Inlet Invert= 105.25', Outlet Invert= 104.22'
6.0" Diameter Pipe n= 0.011 Length= 36.0' Slope= 0.0286 '/'

Reach 2R: DMH-3 to Ex-CB



Pond 1P: Infiltration Field

Soil Type is Sand...Rawls Rate of 8.27 in/hr used for exfiltration rate (0.011486 ft/min)

Inflow Area =	8,310 sf,	Inflow Depth =	4.23"	for	10 yr event
Inflow =	0.87 cfs @	12.09 hrs,	Volume=	2,932 cf	
Outflow =	0.43 cfs @	12.26 hrs,	Volume=	2,922 cf,	Atten= 50%, Lag= 9.7 min
Discarded =	0.24 cfs @	11.95 hrs,	Volume=	2,717 cf	
Primary =	0.20 cfs @	12.26 hrs,	Volume=	204 cf	

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 105.37' @ 12.26 hrs Surf.Area= 1,233 sf Storage= 571 cf
Plug-Flow detention time= 18.1 min calculated for 2,912 cf (99% of inflow)
Center-of-Mass det. time= 16.4 min (752.6 - 736.1)

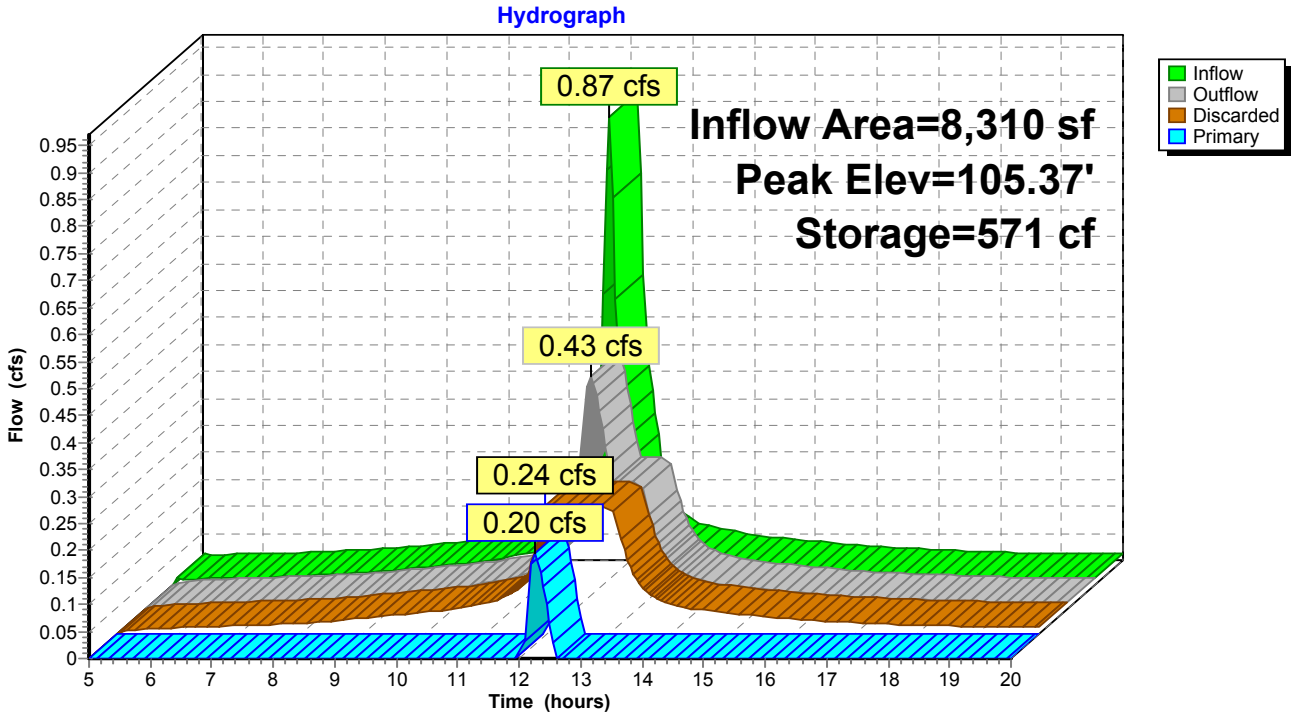
#	Invert	Avail.Storage	Storage Description
1	104.80'	8,843 cf	**18.00'W x 68.50'L x 18.50'H Prismatoid** 22,811 cf Overall - 703 cf Embedded = 22,107 cf x 40.0% Voids
2	104.80'	703 cf	**36.0"W x 12.5"H x 7.50'L Parabolic Arch** x 45 Inside #1
		9,546 cf	Total Available Storage

#	Routing	Invert	Outlet Devices
1	Discarded	0.00'	**0.011486 fpm Exfiltration over entire Surface area**
2	Primary	105.25'	**6.0" Horiz. Orifice/Grate** Limited to weir flow C= 0.600

Discarded OutFlow Max=0.24 cfs @ 11.95 hrs HW=104.99' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.24 cfs)

Primary OutFlow Max=0.20 cfs @ 12.26 hrs HW=105.37' (Free Discharge)
└─**2=Orifice/Grate** (Weir Controls 0.20 cfs @ 1.1 fps)

Pond 1P: Infiltration Field



Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Roof Runoff Area=8,310 sf Runoff Depth=6.24"
Tc=6.0 min CN=98 Runoff=1.28 cfs 4,320 cf

Reach 1R: DMH-1 To DMH-2 Peak Depth=0.67' Max Vel=3.2 fps Inflow=1.28 cfs 4,320 cf
D=8.0" n=0.011 L=53.0' S=0.0049 '/' Capacity=1.00 cfs Outflow=1.00 cfs 4,317 cf

Reach 2R: DMH-3 to Ex-CB Peak Depth=0.25' Max Vel=5.7 fps Inflow=0.55 cfs 755 cf
D=6.0" n=0.011 L=36.0' S=0.0286 '/' Capacity=1.12 cfs Outflow=0.55 cfs 755 cf

Pond 1P: Infiltration Field Peak Elev=105.60' Storage=766 cf Inflow=1.00 cfs 4,317 cf
Discarded=0.24 cfs 3,546 cf Primary=0.55 cfs 755 cf Outflow=0.79 cfs 4,302 cf

Total Runoff Area = 8,310 sf Runoff Volume = 4,320 cf Average Runoff Depth = 6.24"

Subcatchment 1S: Roof

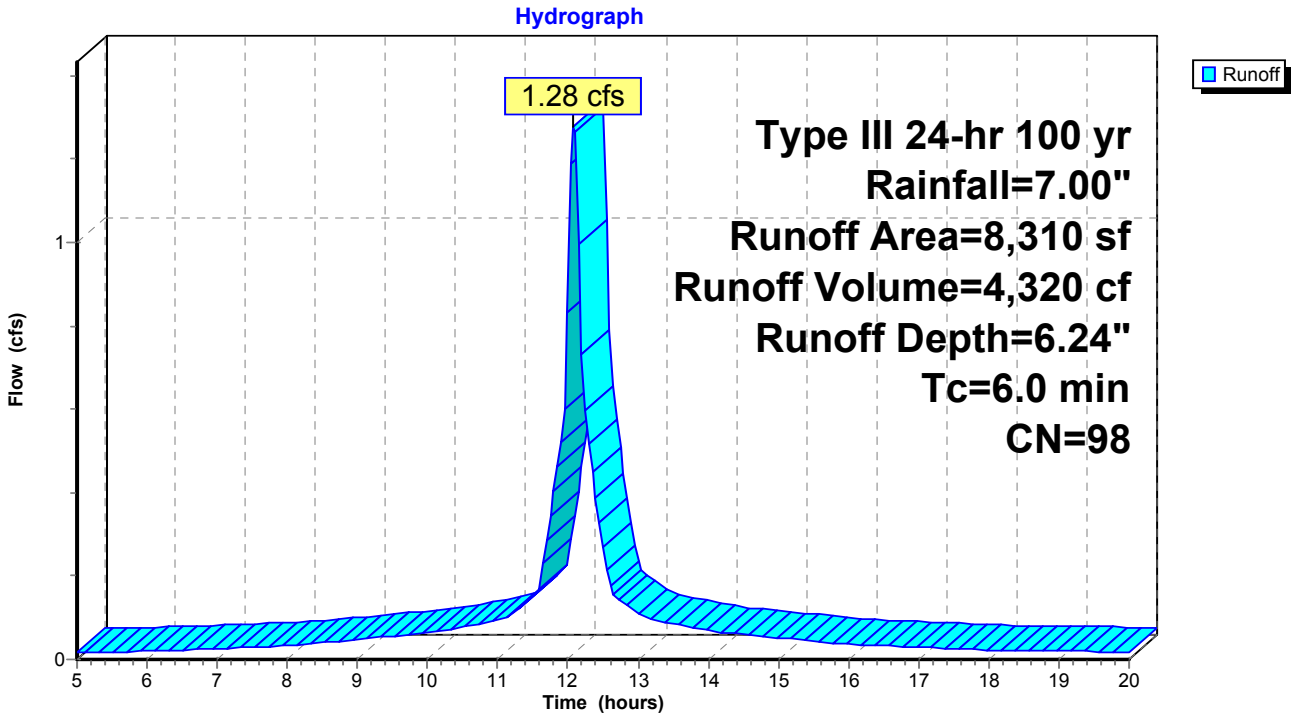
Runoff = 1.28 cfs @ 12.09 hrs, Volume= 4,320 cf, Depth= 6.24"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 yr Rainfall=7.00"

Area (sf)	CN	Description
8,310	98	Ex. Roof Area of Building + Rear Addition

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

Subcatchment 1S: Roof



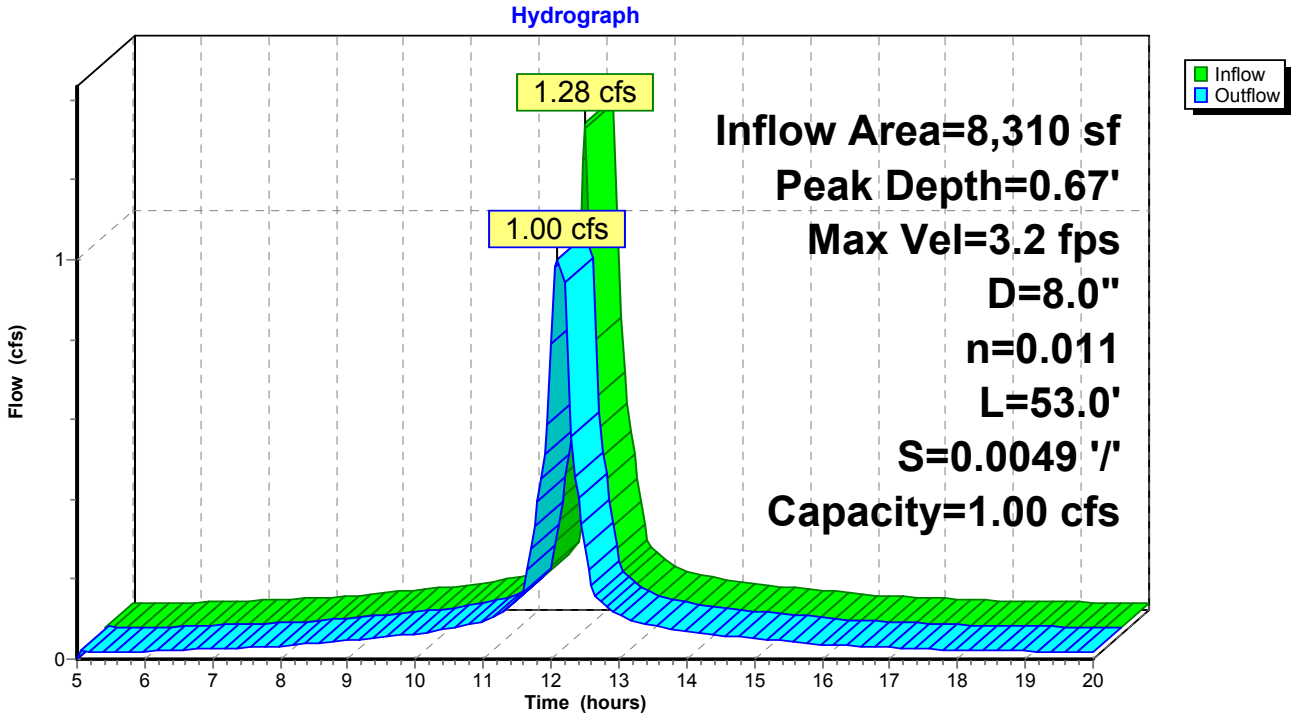
Reach 1R: DMH-1 To DMH-2

Inflow Area = 8,310 sf, Inflow Depth = 6.24" for 100 yr event
Inflow = 1.28 cfs @ 12.09 hrs, Volume= 4,320 cf
Outflow = 1.00 cfs @ 12.10 hrs, Volume= 4,317 cf, Atten= 22%, Lag= 0.8 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.2 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.5 fps, Avg. Travel Time= 0.6 min

Peak Depth= 0.67' @ 12.05 hrs
Capacity at bank full= 1.00 cfs
Inlet Invert= 105.16', Outlet Invert= 104.90'
8.0" Diameter Pipe n= 0.011 Length= 53.0' Slope= 0.0049 '/'

Reach 1R: DMH-1 To DMH-2



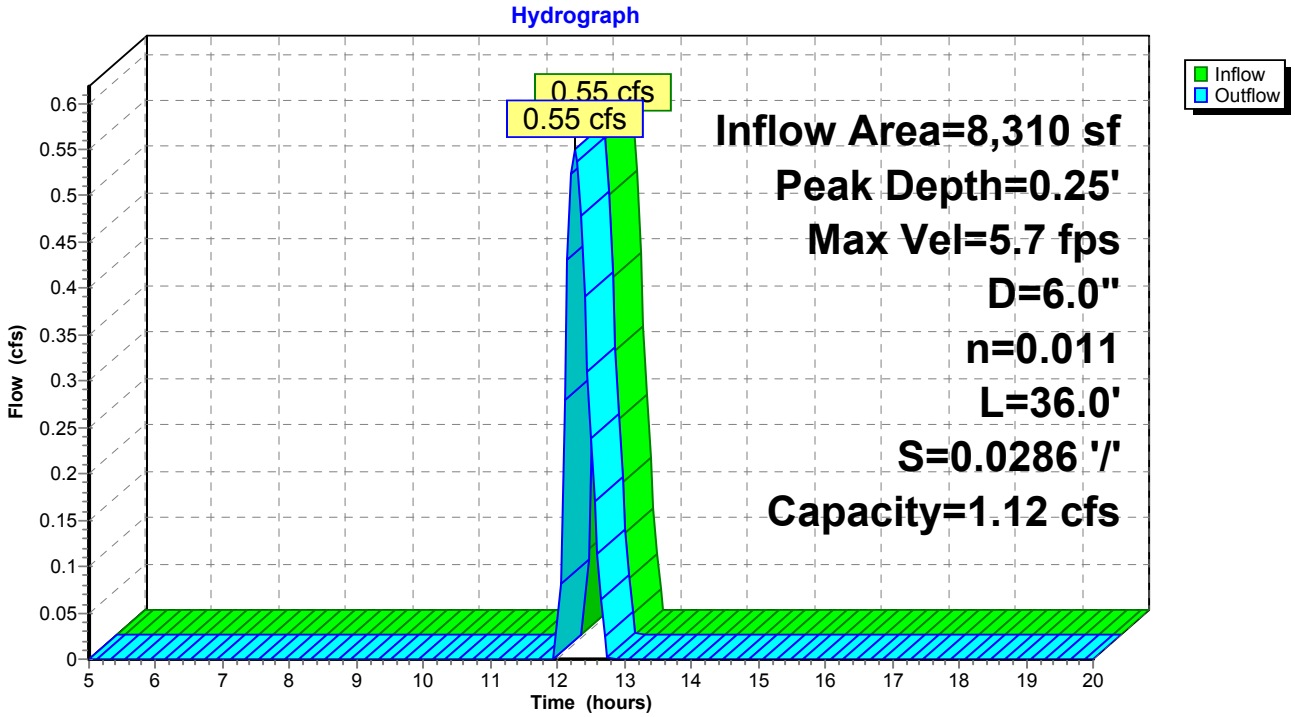
Reach 2R: DMH-3 to Ex-CB

Inflow Area = 8,310 sf, Inflow Depth = 1.09" for 100 yr event
Inflow = 0.55 cfs @ 12.25 hrs, Volume= 755 cf
Outflow = 0.55 cfs @ 12.26 hrs, Volume= 755 cf, Atten= 0%, Lag= 0.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.7 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 4.3 fps, Avg. Travel Time= 0.1 min

Peak Depth= 0.25' @ 12.26 hrs
Capacity at bank full= 1.12 cfs
Inlet Invert= 105.25', Outlet Invert= 104.22'
6.0" Diameter Pipe n= 0.011 Length= 36.0' Slope= 0.0286 '/'

Reach 2R: DMH-3 to Ex-CB



Pond 1P: Infiltration Field

Soil Type is Sand...Rawls Rate of 8.27 in/hr used for exfiltration rate (0.011486 ft/min)

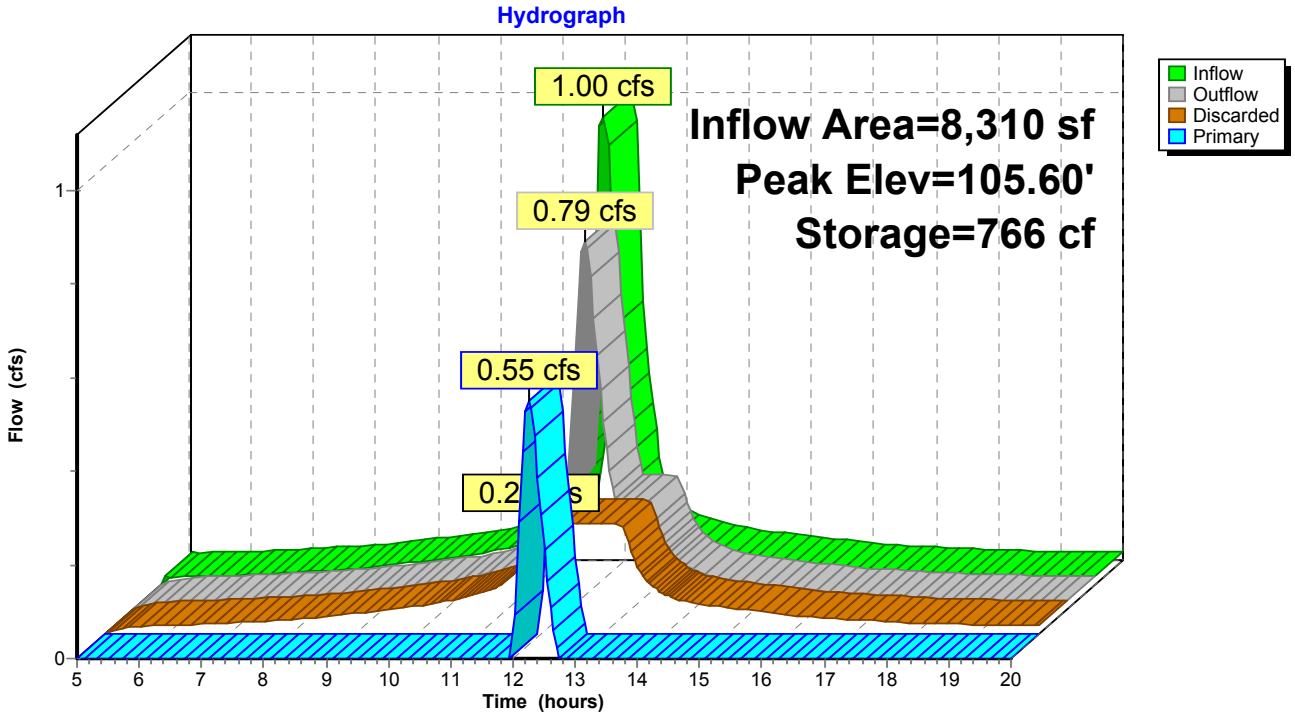
Inflow Area =	8,310 sf,	Inflow Depth =	6.23"	for	100 yr event
Inflow =	1.00 cfs @	12.10 hrs,	Volume=	4,317 cf	
Outflow =	0.79 cfs @	12.25 hrs,	Volume=	4,302 cf,	Atten= 21%, Lag= 9.3 min
Discarded =	0.24 cfs @	11.85 hrs,	Volume=	3,546 cf	
Primary =	0.55 cfs @	12.25 hrs,	Volume=	755 cf	

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 105.60' @ 12.25 hrs Surf.Area= 1,233 sf Storage= 766 cf
Plug-Flow detention time= 17.1 min calculated for 4,302 cf (100% of inflow)
Center-of-Mass det. time= 15.5 min (750.0 - 734.4)

#	Invert	Avail.Storage	Storage Description
1	104.80'	8,843 cf	**18.00'W x 68.50'L x 18.50'H Prismatoid**
			22,811 cf Overall - 703 cf Embedded = 22,107 cf x 40.0% Voids
2	104.80'	703 cf	**36.0"W x 12.5"H x 7.50'L Parabolic Arch** x 45 Inside #1
		9,546 cf	Total Available Storage

#	Routing	Invert	Outlet Devices
1	Discarded	0.00'	**0.011486 fpm Exfiltration over entire Surface area**
2	Primary	105.25'	**6.0" Horiz. Orifice/Grate** Limited to weir flow C= 0.600

Discarded OutFlow Max=0.24 cfs @ 11.85 hrs HW=105.01' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.24 cfs)

Primary OutFlow Max=0.55 cfs @ 12.25 hrs HW=105.59' (Free Discharge)
└─**2=Orifice/Grate** (Orifice Controls 0.55 cfs @ 2.8 fps)

Pond 1P: Infiltration Field