Stormwater Management System Report
Addendum 2

CEC SOLAR #1056 LLC

PROPOSED SOLAR PANEL ARRAY INSTALLATION

207 PROVIDENCE ROAD
GRAFTON, MASSACHUSETTS

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Project No. 2035

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CONSULTING ENGINEERS

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Section 1

Hydrologic Overview

1.0 Purpose of Addendum

The purpose of this Addendum is to address additional comments received from the Planning Board consultant during their review of our stormwater management system design and calculations that accompanied our Site Plan Review and Special Permit petitions. We have made some minor revisions to the design of the stormwater management system and performed updated Post-Development Calculations to address the comments received and the results of this work is provided below.

1.1 Pre-Development Hydrologic Summary

A summary of the pre development hydrologic conditions for the 2, 10, 25, and 100-year storm events is submitted in Table 1.1below. These numbers remain unchanged from the previous submittal.

Table 1.1 – Pre Development Hydrologic Summary

Storm Event	Analysis Point AP-1 Rate of Flow (c.f.s.)	Analysis Point AP-2 Rate of Flow (c.f.s.)
2-year storm	1.99	3.66
10-year storm	4.85	9.22
25-year storm	7.37	14.18
100-year storm	12.92	25.16

1.2 Revised Post Development Hydrologic Summary

As stated above, we have reviewed and revised the stormwater management system design including the design of the two proposed detention basins in order to address minor additional comments from the Planning Board consultant.

A summary of the revised post-development hydrologic conditions for the 2, 10, 25 and 100-year storm events is submitted in Table 1.4 below.

Table 1.2 – Post Development Hydrologic Summary

Storm Event	Analysis Point AP-1 Rate of Flow (c.f.s.)	Analysis Point AP-2 Rate of Flow (c.f.s.)
2-year storm	1.53	2.00
10-year storm	2.54	7.58
25-year storm	3.13	13.27
100-year storm	8.99	22.13

A summary of the pre and post-development hydrologic conditions for the 2, 10, 25, and 100-year storm events is submitted in Table 1.3 below. Results shown as a “negative” represent a decrease in post development condition rates of runoff.

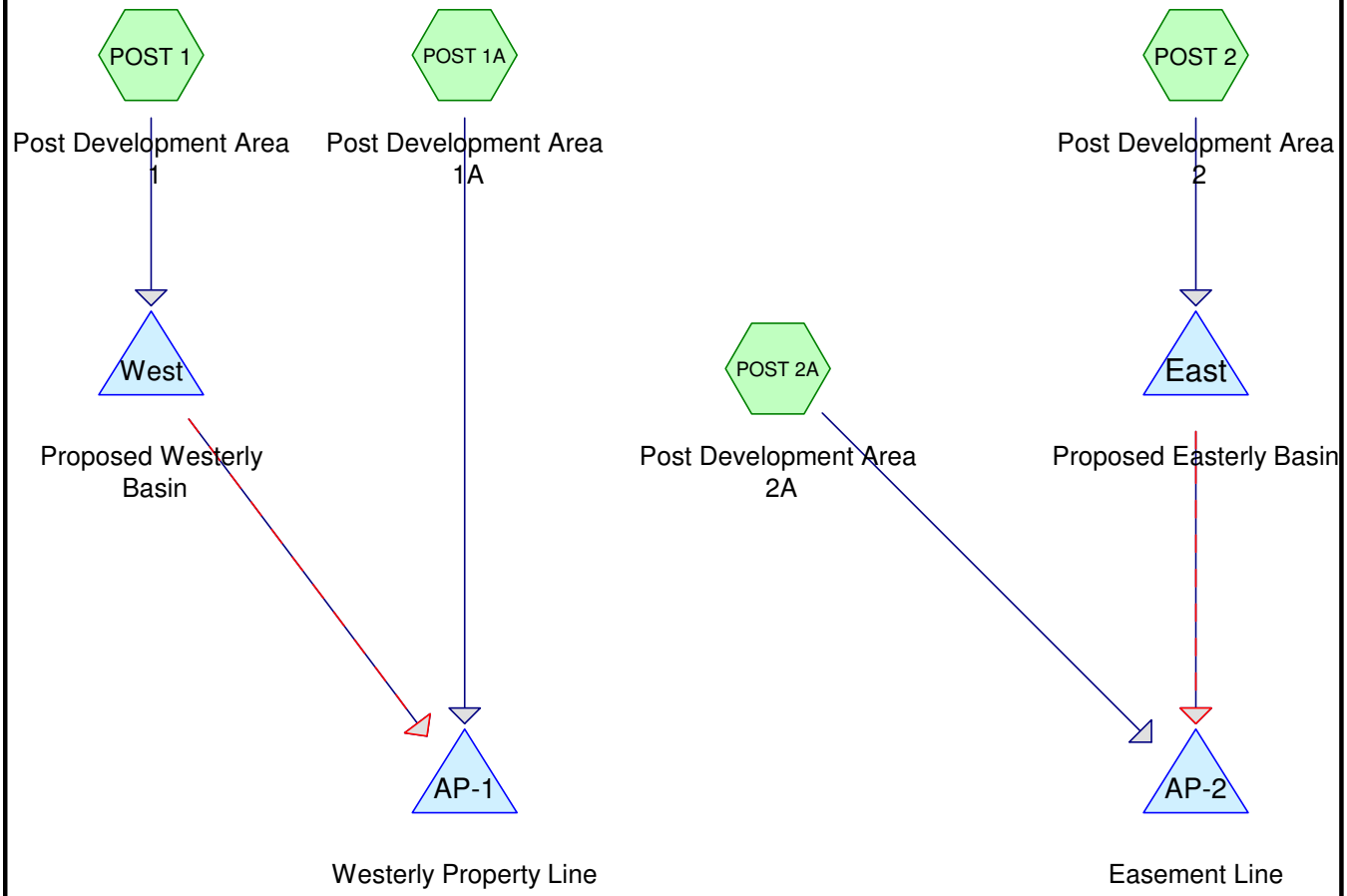
Table 1.3 – Pre-Post Development Hydrologic Results

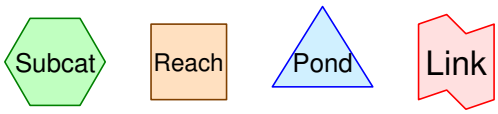
Storm Event	Analysis Point AP-1 Rate of Flow	Analysis Point AP-2 Rate of Flow
2-year storm	-23.1%	-45.3%
10-year storm	-47.6%	-17.8%
25-year storm	-57.5%	-6.4%
100-year storm	-30.4%	-12.0%

The hydrologic analysis indicates that the stormwater management system design for the site meets or reduces peak runoff rates for the 2, 10, 25, and 100 year, 24 hour, Type III storm events from the pre developed levels at the subject analysis points. The analysis shows the proposed development of this project area will not result in an increase in the rates of runoff from the project site.

Section 2

Revised Post Development Hydrologic Analysis





Routing Diagram for 2035-PostDevelopmentAnalysis-R3
Prepared by Field Engineering Co. Inc.
HydroCAD® 10.00-12 s/n 01897 © 2014 HydroCAD Software Solutions LLC

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 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 POST 1: Post Runoff Area=133,997 sf 25.97% Impervious Runoff Depth>1.36"
Flow Length=800' Tc=12.4 min UI Adjusted CN=79 Runoff=3.93 cfs 0.349 af

Subcatchment POST 1A: Post Development Runoff Area=11,440 sf 0.00% Impervious Runoff Depth>1.06"
Tc=6.0 min CN=74 Runoff=0.31 cfs 0.023 af

Subcatchment POST 2: Post Runoff Area=148,565 sf 27.98% Impervious Runoff Depth>1.36"
Flow Length=600' Tc=12.5 min UI Adjusted CN=79 Runoff=4.35 cfs 0.387 af

Subcatchment POST 2A: Post Runoff Area=57,979 sf 28.53% Impervious Runoff Depth>1.30"
Tc=12.0 min UI Adjusted CN=78 Runoff=1.63 cfs 0.144 af

Pond AP-1: Westerly Property Line Inflow=1.53 cfs 0.356 af
Primary=1.53 cfs 0.356 af

Pond AP-2: Easement Line Inflow=2.00 cfs 0.521 af
Primary=2.00 cfs 0.521 af

Pond East: Proposed Easterly Basin Peak Elev=187.59' Storage=6,905 cf Inflow=4.35 cfs 0.387 af
Primary=0.87 cfs 0.377 af Secondary=0.00 cfs 0.000 af Outflow=0.87 cfs 0.377 af

Pond West: Proposed Westerly Basin Peak Elev=161.84' Storage=4,775 cf Inflow=3.93 cfs 0.349 af
Primary=1.45 cfs 0.333 af Secondary=0.00 cfs 0.000 af Outflow=1.45 cfs 0.333 af

Total Runoff Area = 8.080 ac Runoff Volume = 0.904 af Average Runoff Depth = 1.34"
73.60% Pervious = 5.947 ac 26.40% Impervious = 2.133 ac

Summary for Subcatchment POST 1: Post Development Area 1

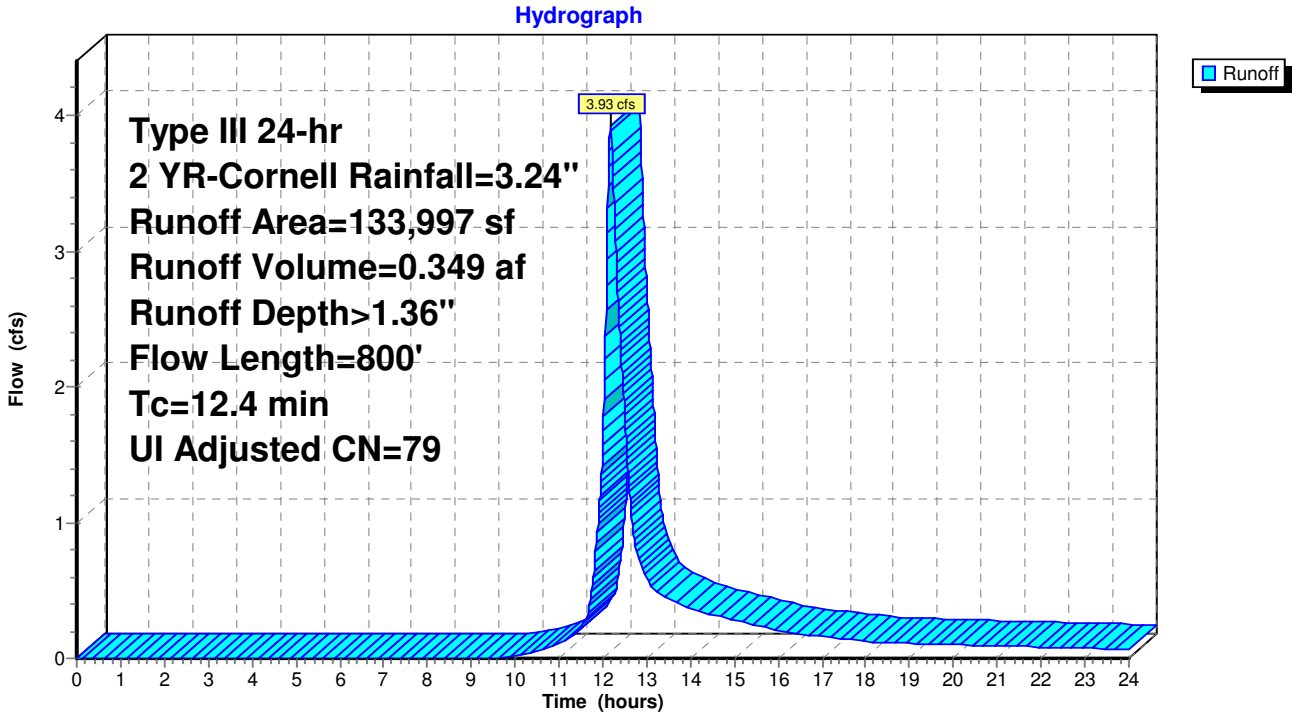
Runoff = 3.93 cfs @ 12.18 hrs, Volume= 0.349 af, Depth> 1.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YR-Cornell Rainfall=3.24"

	Area (sf)	CN	Adj	Description
	13,060	89		Gravel roads, HSG C
	8,168	72		Woods/grass comb., Good, HSG C
	77,969	74		Pasture/grassland/range, Good, HSG C
	33,972	98		Unconnected pavement, HSG C
*	828	98		Concrete Equipment Pads
	133,997	82	79	Weighted Average, UI Adjusted
	99,197			74.03% Pervious Area
	34,800			25.97% Impervious Area
	33,972			97.62% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.5	350	0.1100	2.32		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.6	400	0.1200	11.99	4.19	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.4	800	Total			

Subcatchment POST 1: Post Development Area 1



Summary for Subcatchment POST 1A: Post Development Area 1A

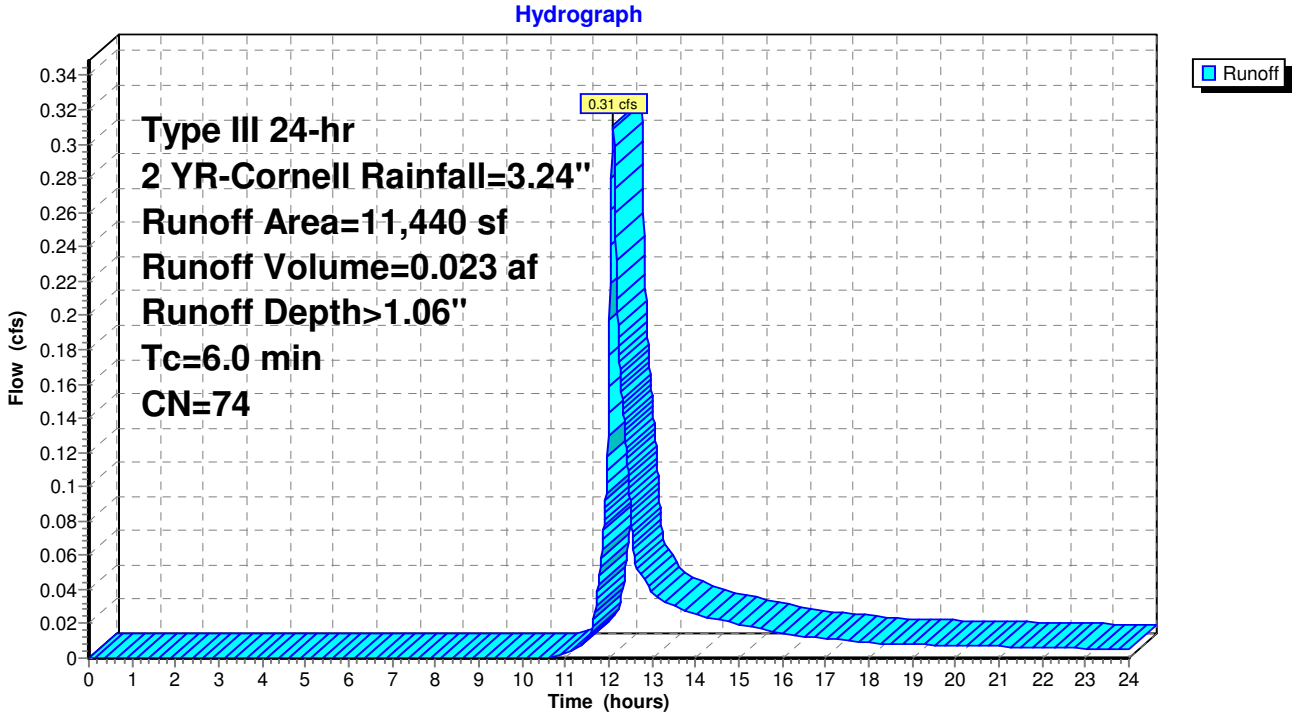
Runoff = 0.31 cfs @ 12.10 hrs, Volume= 0.023 af, Depth> 1.06"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YR-Cornell Rainfall=3.24"

Area (sf)	CN	Description
285	89	Gravel roads, HSG C
11,155	74	>75% Grass cover, Good, HSG C
11,440	74	Weighted Average
11,440		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Assume 6.0 Minutes-Min Tc**

Subcatchment POST 1A: Post Development Area 1A



Summary for Subcatchment POST 2: Post Development Area 2

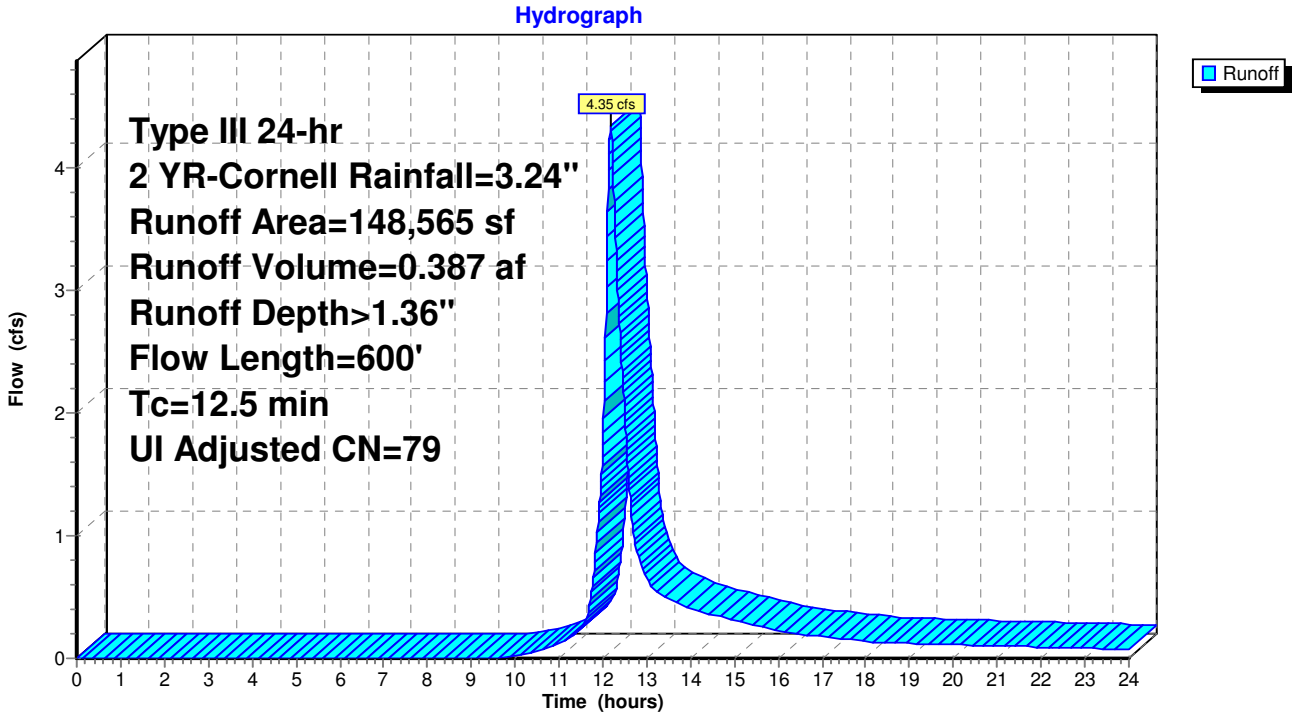
Runoff = 4.35 cfs @ 12.18 hrs, Volume= 0.387 af, Depth> 1.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YR-Cornell Rainfall=3.24"

	Area (sf)	CN	Adj	Description
	84,058	74		Pasture/grassland/range, Good, HSG C
*	41,571	98		Unconnected pavement, HSG C (Panels)
	16,786	89		Gravel roads, HSG C
	6,150	70		Woods, Good, HSG C
	148,565	82	79	Weighted Average, UI Adjusted
	106,994			72.02% Pervious Area
	41,571			27.98% Impervious Area
	41,571			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.9	350	0.0850	2.04		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.3	200	0.1400	12.95	4.52	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.5	600	Total			

Subcatchment POST 2: Post Development Area 2



Summary for Subcatchment POST 2A: Post Development Area 2A

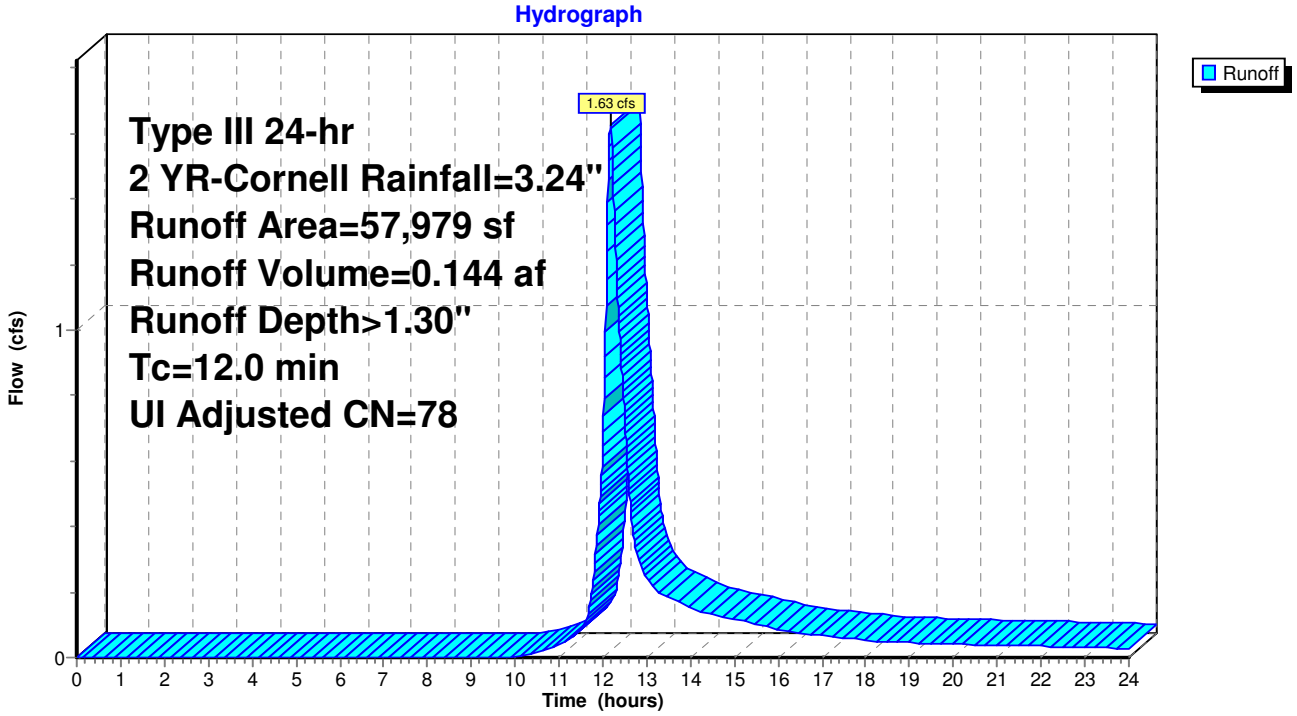
Runoff = 1.63 cfs @ 12.17 hrs, Volume= 0.144 af, Depth> 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YR-Cornell Rainfall=3.24"

Area (sf)	CN	Adj	Description
40,371	74		>75% Grass cover, Good, HSG C
16,539	98		Unconnected roofs, HSG C
1,069	89		Gravel roads, HSG C
57,979	81	78	Weighted Average, UI Adjusted
41,440			71.47% Pervious Area
16,539			28.53% Impervious Area
16,539			100.00% Unconnected

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

Subcatchment POST 2A: Post Development Area 2A



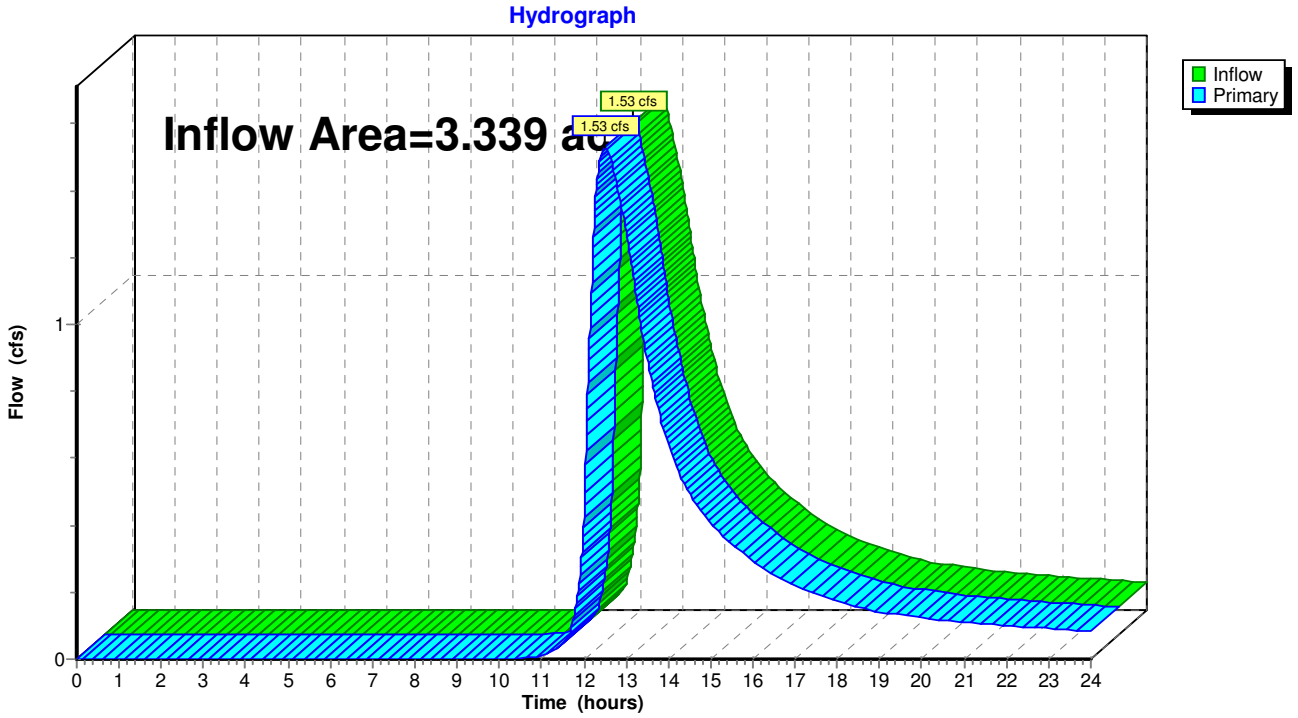
Summary for Pond AP-1: Westerly Property Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	3.339 ac,	23.93% Impervious,	Inflow Depth >	1.28"	for 2 YR-Cornell event
Inflow =	1.53 cfs @	12.49 hrs,	Volume=	0.356 af	
Primary =	1.53 cfs @	12.49 hrs,	Volume=	0.356 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-1: Westerly Property Line



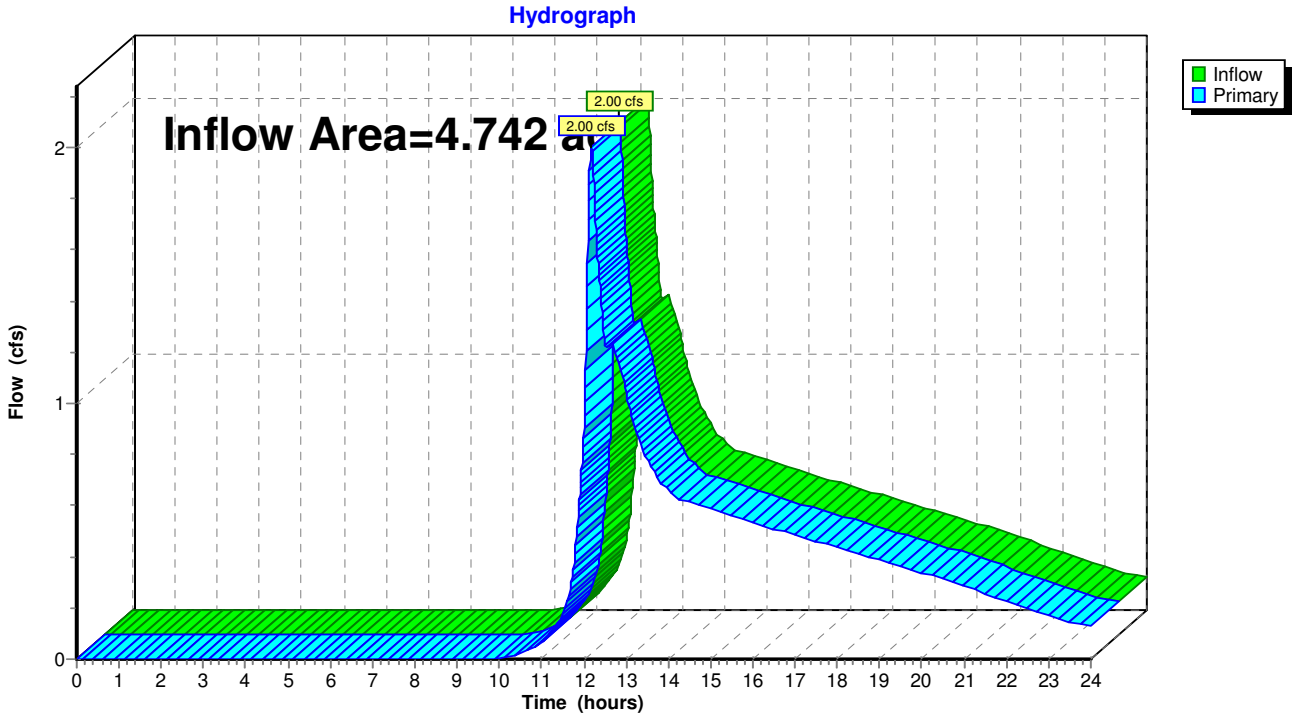
Summary for Pond AP-2: Easement Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	4.742 ac,	28.13% Impervious,	Inflow Depth >	1.32"	for 2 YR-Cornell event
Inflow =	2.00 cfs @	12.18 hrs,	Volume=	0.521 af	
Primary =	2.00 cfs @	12.18 hrs,	Volume=	0.521 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-2: Easement Line



Summary for Pond East: Proposed Easterly Basin

Inflow Area = 3.411 ac, 27.98% Impervious, Inflow Depth > 1.36" for 2 YR-Cornell event
Inflow = 4.35 cfs @ 12.18 hrs, Volume= 0.387 af
Outflow = 0.87 cfs @ 12.77 hrs, Volume= 0.377 af, Atten= 80%, Lag= 35.6 min
Primary = 0.87 cfs @ 12.77 hrs, Volume= 0.377 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 187.59' @ 12.77 hrs Surf.Area= 5,992 sf Storage= 6,905 cf

Plug-Flow detention time= 154.6 min calculated for 0.377 af (97% of inflow)
Center-of-Mass det. time= 139.2 min (988.8 - 849.6)

Volume	Invert	Avail.Storage	Storage Description
#1	186.00'	24,433 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

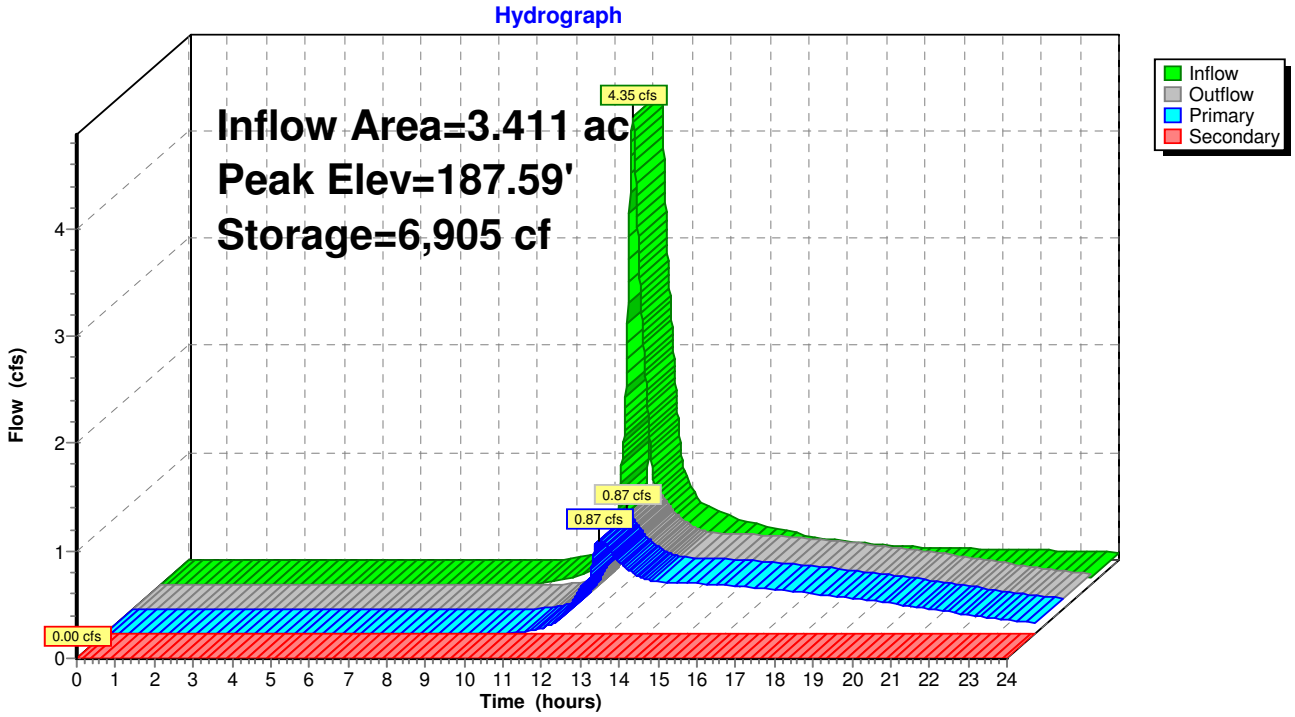
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
186.00	1,685	0	0
187.00	5,388	3,537	3,537
188.00	6,408	5,898	9,435
189.00	7,485	6,947	16,381
190.00	8,618	8,052	24,433

Device	Routing	Invert	Outlet Devices
#1	Primary	185.00'	**18.0" Round Culvert** L= 26.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 185.00' / 184.75' S= 0.0096 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.77 sf
#2	Device 1	186.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	187.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	189.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=0.86 cfs @ 12.77 hrs HW=187.59' (Free Discharge)
└─**1=Culvert** (Passes 0.86 cfs of 11.55 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.50 cfs @ 5.75 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Weir Controls 0.36 cfs @ 0.99 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=186.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond East: Proposed Easterly Basin



Summary for Pond West: Proposed Westerly Basin

Inflow Area =	3.076 ac, 25.97% Impervious, Inflow Depth > 1.36" for 2 YR-Cornell event				
Inflow =	3.93 cfs @	12.18 hrs,	Volume=	0.349 af	
Outflow =	1.45 cfs @	12.56 hrs,	Volume=	0.333 af,	Atten= 63%, Lag= 23.3 min
Primary =	1.45 cfs @	12.56 hrs,	Volume=	0.333 af	
Secondary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 161.84' @ 12.56 hrs Surf.Area= 6,376 sf Storage= 4,775 cf

Plug-Flow detention time= 74.9 min calculated for 0.333 af (95% of inflow)
Center-of-Mass det. time= 49.1 min (898.7 - 849.5)

Volume	Invert	Avail.Storage	Storage Description
#1	161.00'	33,550 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

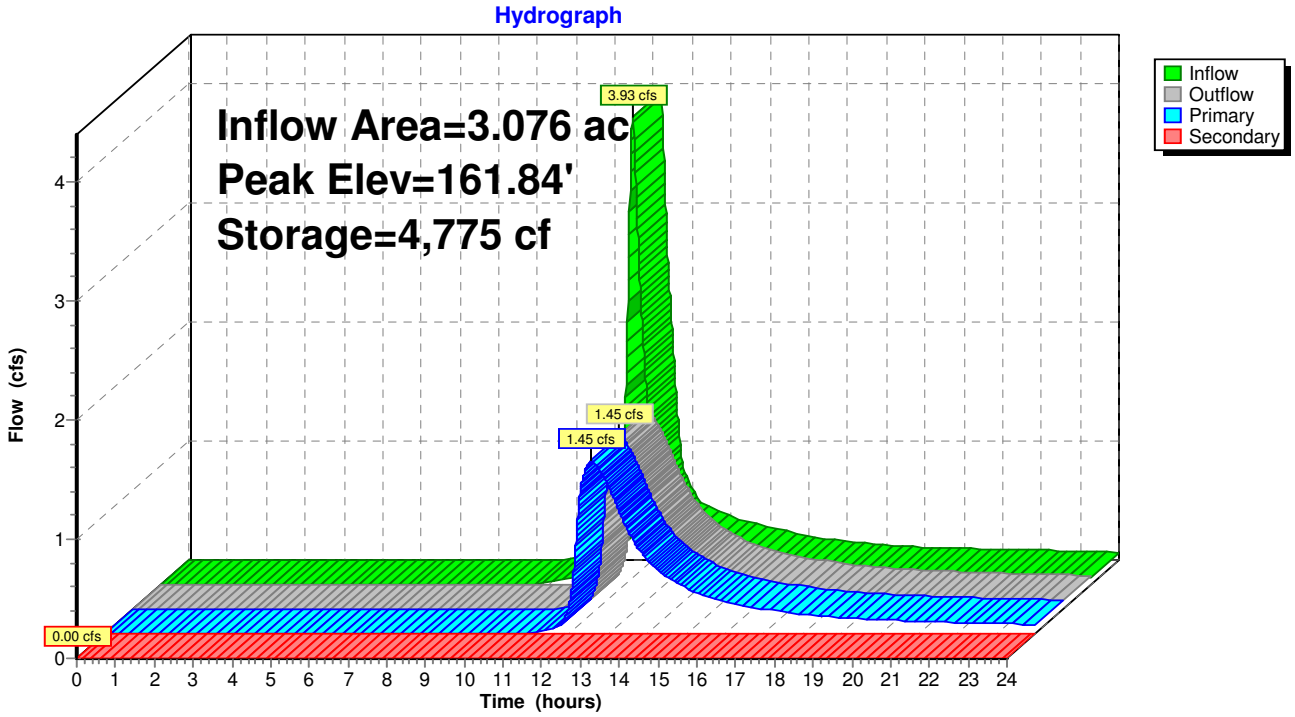
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
161.00	4,989	0	0
162.00	6,639	5,814	5,814
163.00	8,345	7,492	13,306
164.00	10,108	9,227	22,533
165.00	11,927	11,018	33,550

Device	Routing	Invert	Outlet Devices
#1	Primary	160.00'	**15.0" Round Culvert** L= 32.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 160.00' / 159.50' S= 0.0156 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.23 sf
#2	Device 1	161.00'	**9.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	163.35'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	164.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=1.45 cfs @ 12.56 hrs HW=161.84' (Free Discharge)
└─**1=Culvert** (Passes 1.45 cfs of 5.14 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 1.45 cfs @ 3.28 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=161.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond West: Proposed Westerly Basin



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 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 POST 1: Post Runoff Area=133,997 sf 25.97% Impervious Runoff Depth>2.70"
Flow Length=800' Tc=12.4 min UI Adjusted CN=79 Runoff=7.94 cfs 0.692 af

Subcatchment POST 1A: Post Development Runoff Area=11,440 sf 0.00% Impervious Runoff Depth>2.27"
Tc=6.0 min CN=74 Runoff=0.70 cfs 0.050 af

Subcatchment POST 2: Post Runoff Area=148,565 sf 27.98% Impervious Runoff Depth>2.70"
Flow Length=600' Tc=12.5 min UI Adjusted CN=79 Runoff=8.77 cfs 0.767 af

Subcatchment POST 2A: Post Runoff Area=57,979 sf 28.53% Impervious Runoff Depth>2.61"
Tc=12.0 min UI Adjusted CN=78 Runoff=3.36 cfs 0.290 af

Pond AP-1: Westerly Property Line Inflow=2.54 cfs 0.720 af
Primary=2.54 cfs 0.720 af

Pond AP-2: Easement Line Inflow=7.58 cfs 1.027 af
Primary=7.58 cfs 1.027 af

Pond East: Proposed Easterly Basin Peak Elev=188.03' Storage=9,602 cf Inflow=8.77 cfs 0.767 af
Primary=5.43 cfs 0.737 af Secondary=0.00 cfs 0.000 af Outflow=5.43 cfs 0.737 af

Pond West: Proposed Westerly Basin Peak Elev=162.62' Storage=10,275 cf Inflow=7.94 cfs 0.692 af
Primary=2.38 cfs 0.670 af Secondary=0.00 cfs 0.000 af Outflow=2.38 cfs 0.670 af

Total Runoff Area = 8.080 ac Runoff Volume = 1.799 af Average Runoff Depth = 2.67"
73.60% Pervious = 5.947 ac 26.40% Impervious = 2.133 ac

Summary for Subcatchment POST 1: Post Development Area 1

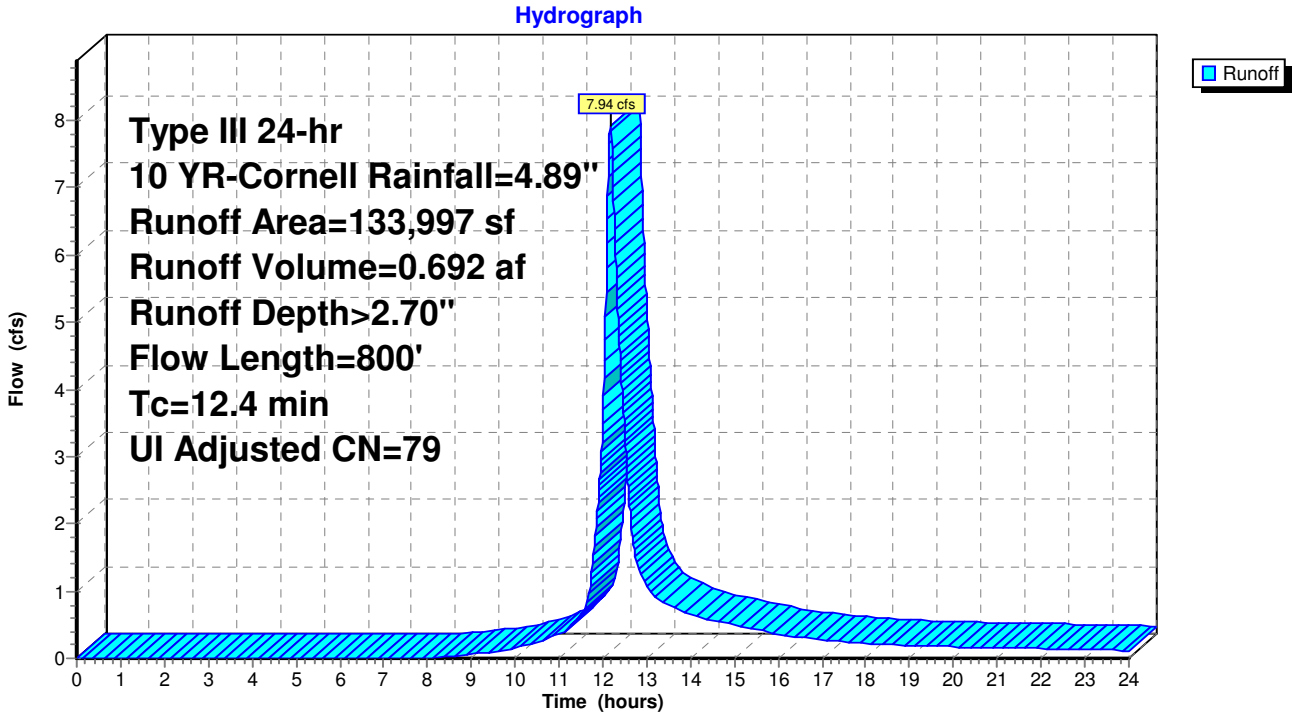
Runoff = 7.94 cfs @ 12.17 hrs, Volume= 0.692 af, Depth> 2.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YR-Cornell Rainfall=4.89"

	Area (sf)	CN	Adj	Description
	13,060	89		Gravel roads, HSG C
	8,168	72		Woods/grass comb., Good, HSG C
	77,969	74		Pasture/grassland/range, Good, HSG C
	33,972	98		Unconnected pavement, HSG C
*	828	98		Concrete Equipment Pads
	133,997	82	79	Weighted Average, UI Adjusted
	99,197			74.03% Pervious Area
	34,800			25.97% Impervious Area
	33,972			97.62% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.5	350	0.1100	2.32		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.6	400	0.1200	11.99	4.19	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.4	800	Total			

Subcatchment POST 1: Post Development Area 1



Summary for Subcatchment POST 1A: Post Development Area 1A

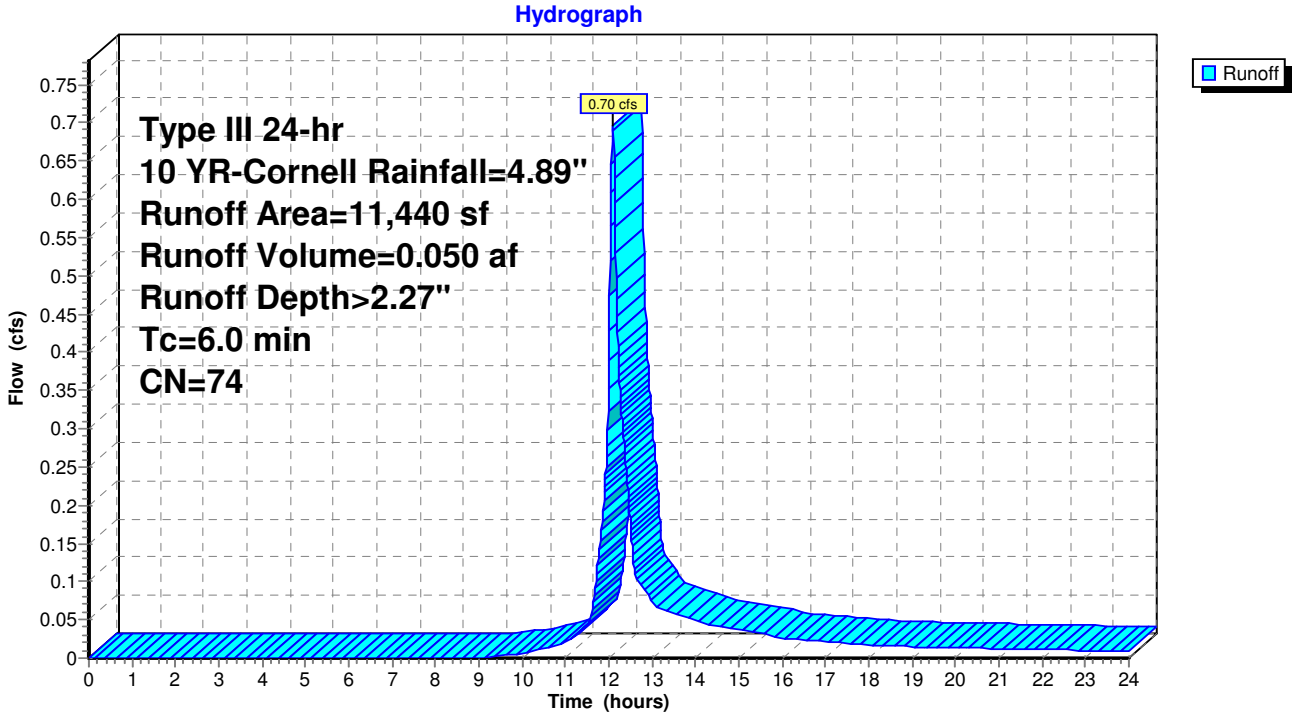
Runoff = 0.70 cfs @ 12.09 hrs, Volume= 0.050 af, Depth> 2.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YR-Cornell Rainfall=4.89"

Area (sf)	CN	Description
285	89	Gravel roads, HSG C
11,155	74	>75% Grass cover, Good, HSG C
11,440	74	Weighted Average
11,440		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Assume 6.0 Minutes-Min Tc**

Subcatchment POST 1A: Post Development Area 1A



Summary for Subcatchment POST 2: Post Development Area 2

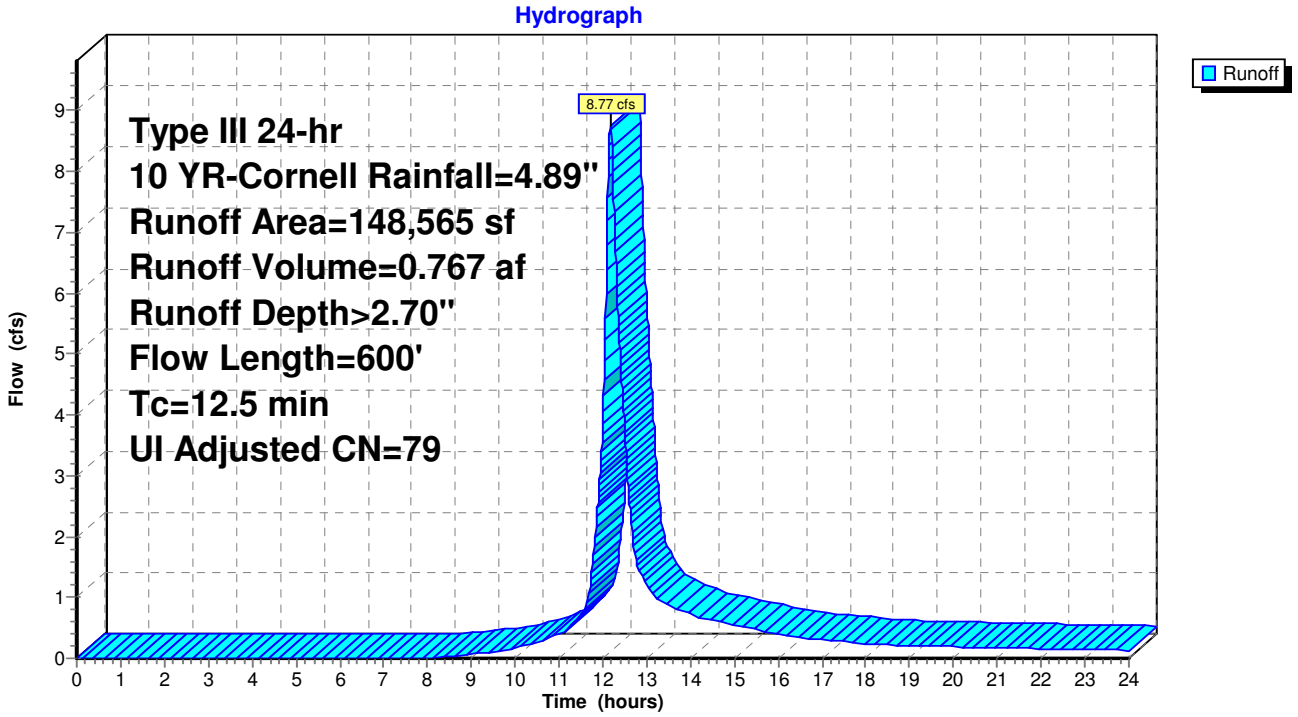
Runoff = 8.77 cfs @ 12.17 hrs, Volume= 0.767 af, Depth> 2.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YR-Cornell Rainfall=4.89"

	Area (sf)	CN	Adj	Description
	84,058	74		Pasture/grassland/range, Good, HSG C
*	41,571	98		Unconnected pavement, HSG C (Panels)
	16,786	89		Gravel roads, HSG C
	6,150	70		Woods, Good, HSG C
	148,565	82	79	Weighted Average, UI Adjusted
	106,994			72.02% Pervious Area
	41,571			27.98% Impervious Area
	41,571			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.9	350	0.0850	2.04		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.3	200	0.1400	12.95	4.52	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.5	600	Total			

Subcatchment POST 2: Post Development Area 2



Summary for Subcatchment POST 2A: Post Development Area 2A

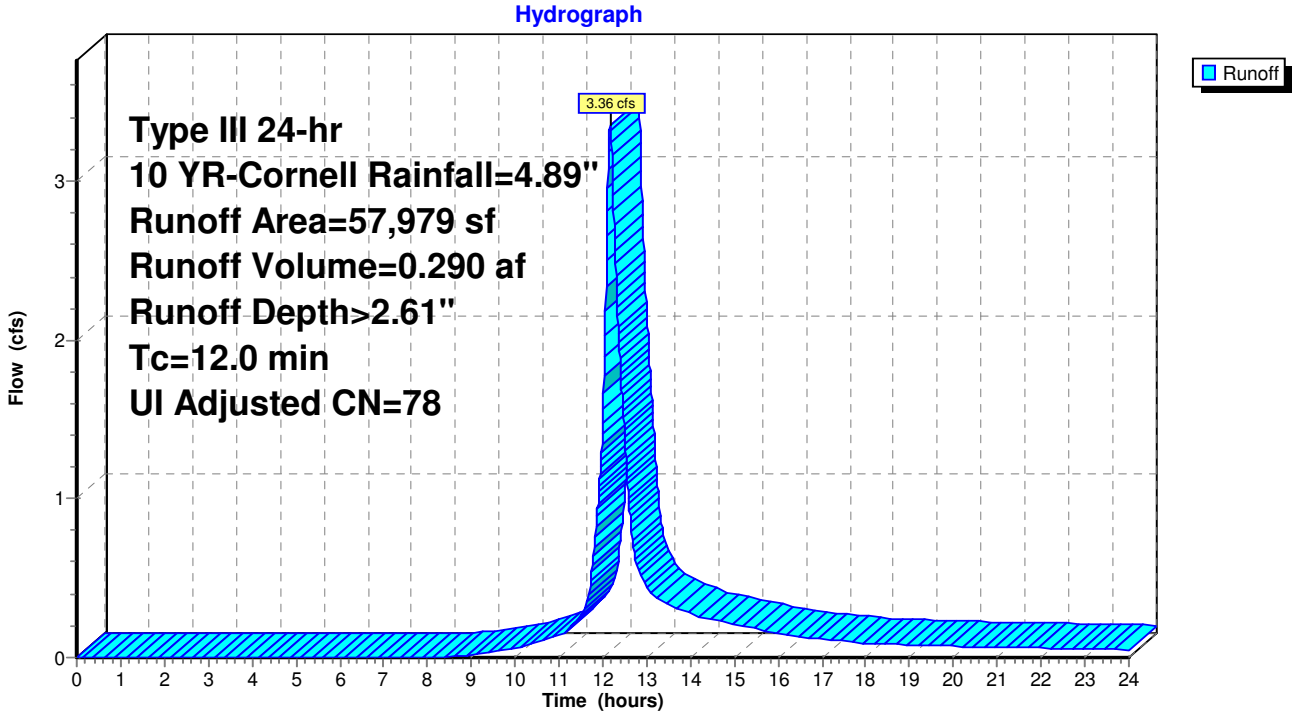
Runoff = 3.36 cfs @ 12.17 hrs, Volume= 0.290 af, Depth> 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YR-Cornell Rainfall=4.89"

Area (sf)	CN	Adj	Description
40,371	74		>75% Grass cover, Good, HSG C
16,539	98		Unconnected roofs, HSG C
1,069	89		Gravel roads, HSG C
57,979	81	78	Weighted Average, UI Adjusted
41,440			71.47% Pervious Area
16,539			28.53% Impervious Area
16,539			100.00% Unconnected

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

Subcatchment POST 2A: Post Development Area 2A



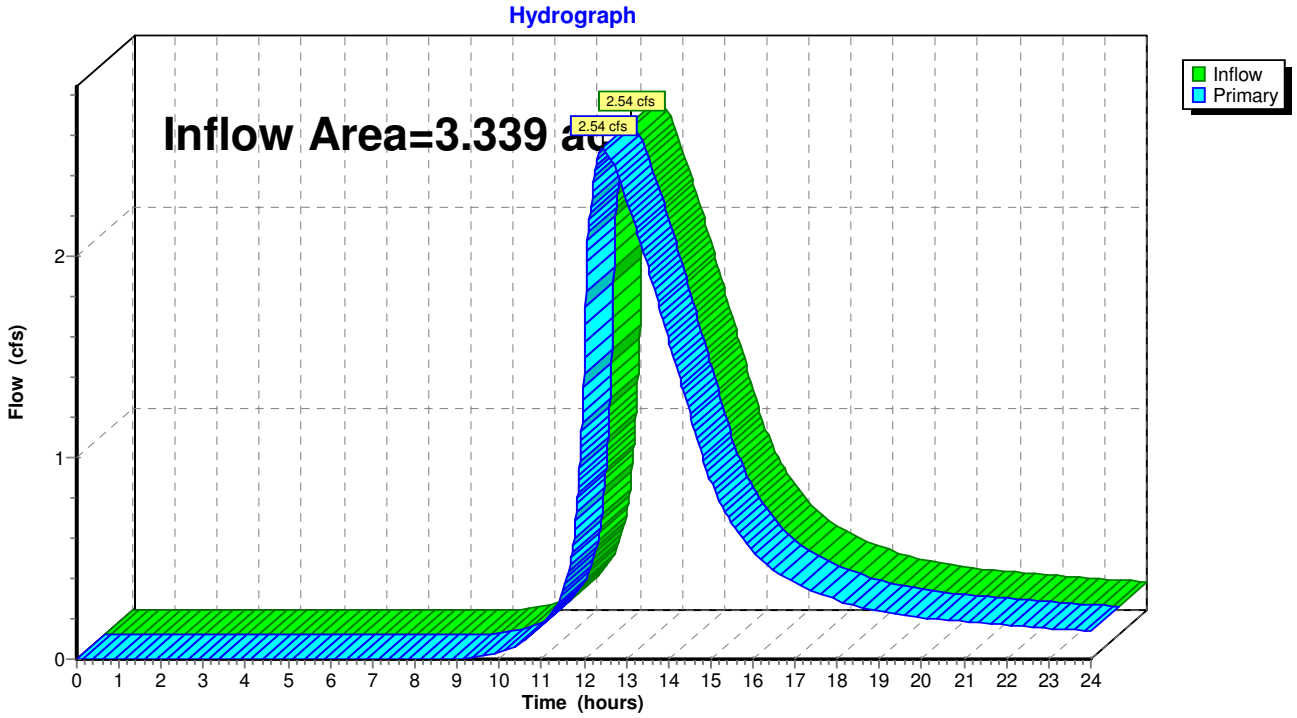
Summary for Pond AP-1: Westerly Property Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	3.339 ac,	23.93% Impervious,	Inflow Depth >	2.59"	for 10 YR-Cornell event
Inflow =	2.54 cfs @	12.45 hrs,	Volume=	0.720 af	
Primary =	2.54 cfs @	12.45 hrs,	Volume=	0.720 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-1: Westerly Property Line



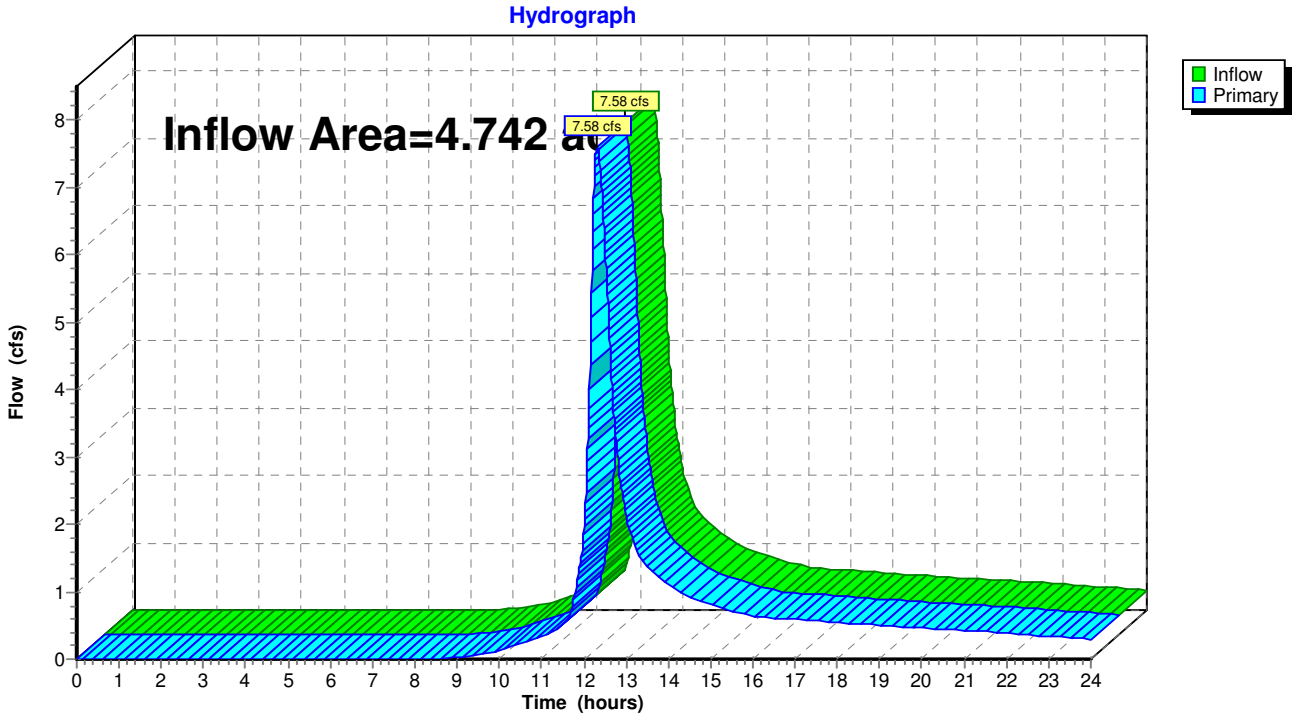
Summary for Pond AP-2: Easement Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	4.742 ac,	28.13% Impervious,	Inflow Depth >	2.60"	for 10 YR-Cornell event
Inflow =	7.58 cfs @	12.32 hrs,	Volume=	1.027 af	
Primary =	7.58 cfs @	12.32 hrs,	Volume=	1.027 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-2: Easement Line



Summary for Pond East: Proposed Easterly Basin

Inflow Area = 3.411 ac, 27.98% Impervious, Inflow Depth > 2.70" for 10 YR-Cornell event
Inflow = 8.77 cfs @ 12.17 hrs, Volume= 0.767 af
Outflow = 5.43 cfs @ 12.36 hrs, Volume= 0.737 af, Atten= 38%, Lag= 11.3 min
Primary = 5.43 cfs @ 12.36 hrs, Volume= 0.737 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 188.03' @ 12.36 hrs Surf.Area= 6,436 sf Storage= 9,602 cf

Plug-Flow detention time= 111.0 min calculated for 0.737 af (96% of inflow)
Center-of-Mass det. time= 89.2 min (919.1 - 829.9)

Volume	Invert	Avail.Storage	Storage Description
#1	186.00'	24,433 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

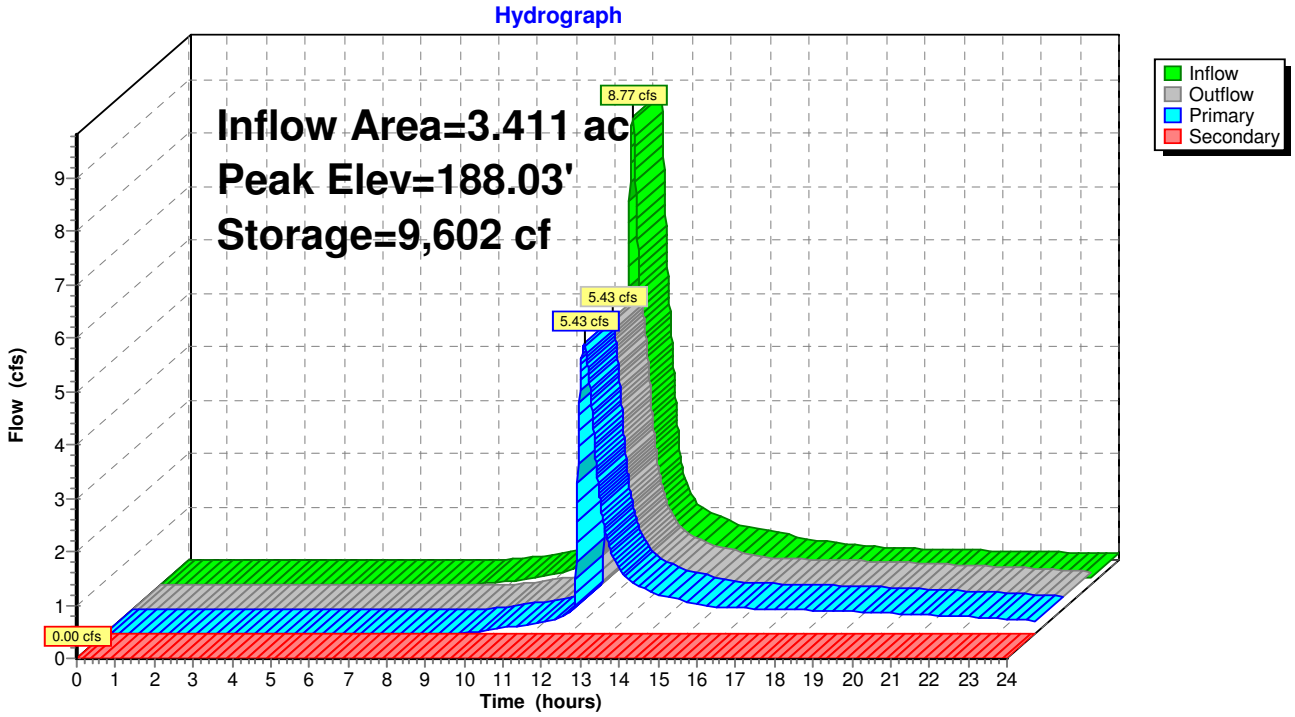
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
186.00	1,685	0	0
187.00	5,388	3,537	3,537
188.00	6,408	5,898	9,435
189.00	7,485	6,947	16,381
190.00	8,618	8,052	24,433

Device	Routing	Invert	Outlet Devices
#1	Primary	185.00'	**18.0" Round Culvert** L= 26.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 185.00' / 184.75' S= 0.0096 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.77 sf
#2	Device 1	186.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	187.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	189.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=5.43 cfs @ 12.36 hrs HW=188.03' (Free Discharge)
└─**1=Culvert** (Passes 5.43 cfs of 12.84 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.57 cfs @ 6.57 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Weir Controls 4.86 cfs @ 2.37 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=186.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond East: Proposed Easterly Basin



Summary for Pond West: Proposed Westerly Basin

Inflow Area =	3.076 ac, 25.97% Impervious, Inflow Depth > 2.70" for 10 YR-Cornell event				
Inflow =	7.94 cfs @	12.17 hrs,	Volume=	0.692 af	
Outflow =	2.38 cfs @	12.60 hrs,	Volume=	0.670 af,	Atten= 70%, Lag= 25.6 min
Primary =	2.38 cfs @	12.60 hrs,	Volume=	0.670 af	
Secondary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 162.62' @ 12.60 hrs Surf.Area= 7,700 sf Storage= 10,275 cf

Plug-Flow detention time= 69.8 min calculated for 0.670 af (97% of inflow)
Center-of-Mass det. time= 51.7 min (881.5 - 829.9)

Volume	Invert	Avail.Storage	Storage Description
#1	161.00'	33,550 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

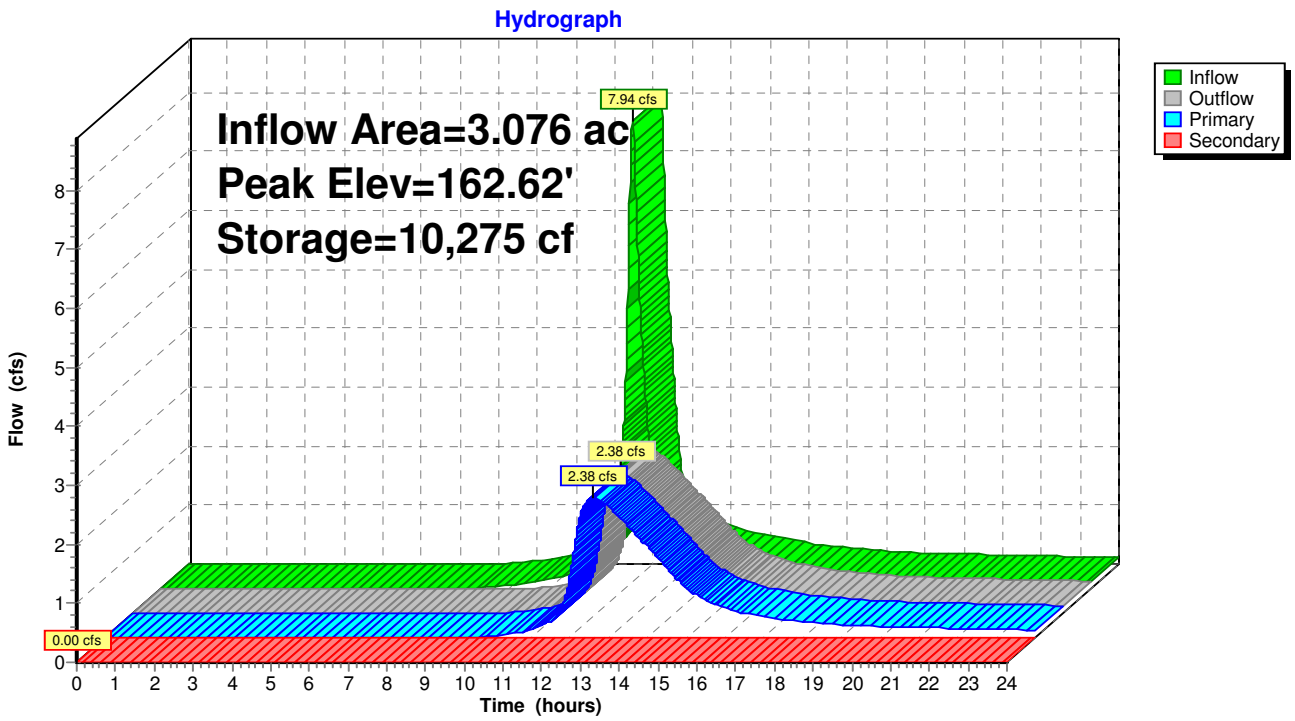
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
161.00	4,989	0	0
162.00	6,639	5,814	5,814
163.00	8,345	7,492	13,306
164.00	10,108	9,227	22,533
165.00	11,927	11,018	33,550

Device	Routing	Invert	Outlet Devices
#1	Primary	160.00'	**15.0" Round Culvert** L= 32.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 160.00' / 159.50' S= 0.0156 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.23 sf
#2	Device 1	161.00'	**9.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	163.35'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	164.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=2.38 cfs @ 12.60 hrs HW=162.62' (Free Discharge)
└─**1=Culvert** (Passes 2.38 cfs of 6.59 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 2.38 cfs @ 5.38 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=161.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond West: Proposed Westerly Basin



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 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 POST 1: Post Runoff Area=133,997 sf 25.97% Impervious Runoff Depth>3.83"
Flow Length=800' Tc=12.4 min UI Adjusted CN=79 Runoff=11.24 cfs 0.982 af

Subcatchment POST 1A: Post Development Runoff Area=11,440 sf 0.00% Impervious Runoff Depth>3.33"
Tc=6.0 min CN=74 Runoff=1.03 cfs 0.073 af

Subcatchment POST 2: Post Runoff Area=148,565 sf 27.98% Impervious Runoff Depth>3.83"
Flow Length=600' Tc=12.5 min UI Adjusted CN=79 Runoff=12.41 cfs 1.089 af

Subcatchment POST 2A: Post Runoff Area=57,979 sf 28.53% Impervious Runoff Depth>3.73"
Tc=12.0 min UI Adjusted CN=78 Runoff=4.79 cfs 0.414 af

Pond AP-1: Westerly Property Line Inflow=3.13 cfs 1.030 af
Primary=3.13 cfs 1.030 af

Pond AP-2: Easement Line Inflow=13.27 cfs 1.451 af
Primary=13.27 cfs 1.451 af

Pond East: Proposed Easterly Basin Peak Elev=188.29' Storage=11,355 cf Inflow=12.41 cfs 1.089 af
Primary=9.48 cfs 1.037 af Secondary=0.00 cfs 0.000 af Outflow=9.48 cfs 1.037 af

Pond West: Proposed Westerly Basin Peak Elev=163.23' Storage=15,286 cf Inflow=11.24 cfs 0.982 af
Primary=2.90 cfs 0.957 af Secondary=0.00 cfs 0.000 af Outflow=2.90 cfs 0.957 af

Total Runoff Area = 8.080 ac Runoff Volume = 2.558 af Average Runoff Depth = 3.80"
73.60% Pervious = 5.947 ac 26.40% Impervious = 2.133 ac

Summary for Subcatchment POST 1: Post Development Area 1

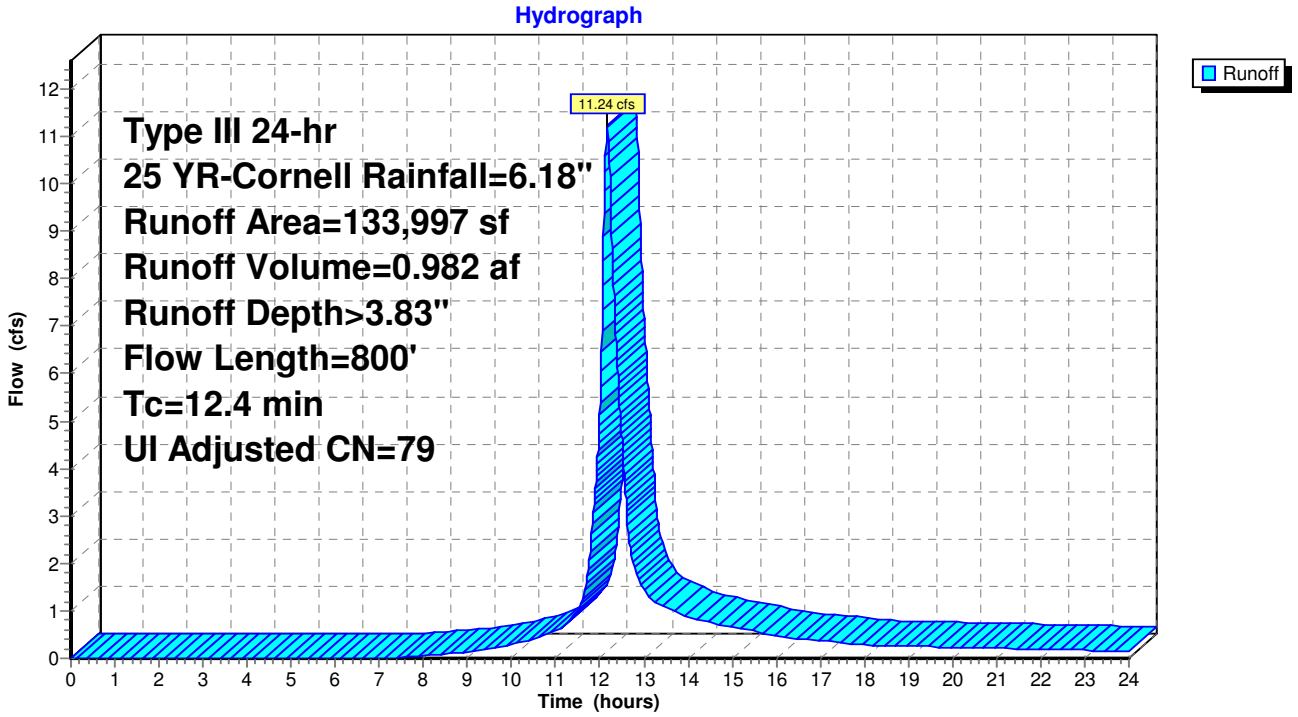
Runoff = 11.24 cfs @ 12.17 hrs, Volume= 0.982 af, Depth> 3.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YR-Cornell Rainfall=6.18"

	Area (sf)	CN	Adj	Description
	13,060	89		Gravel roads, HSG C
	8,168	72		Woods/grass comb., Good, HSG C
	77,969	74		Pasture/grassland/range, Good, HSG C
	33,972	98		Unconnected pavement, HSG C
*	828	98		Concrete Equipment Pads
	133,997	82	79	Weighted Average, UI Adjusted
	99,197			74.03% Pervious Area
	34,800			25.97% Impervious Area
	33,972			97.62% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.5	350	0.1100	2.32		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.6	400	0.1200	11.99	4.19	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.4	800	Total			

Subcatchment POST 1: Post Development Area 1



Summary for Subcatchment POST 1A: Post Development Area 1A

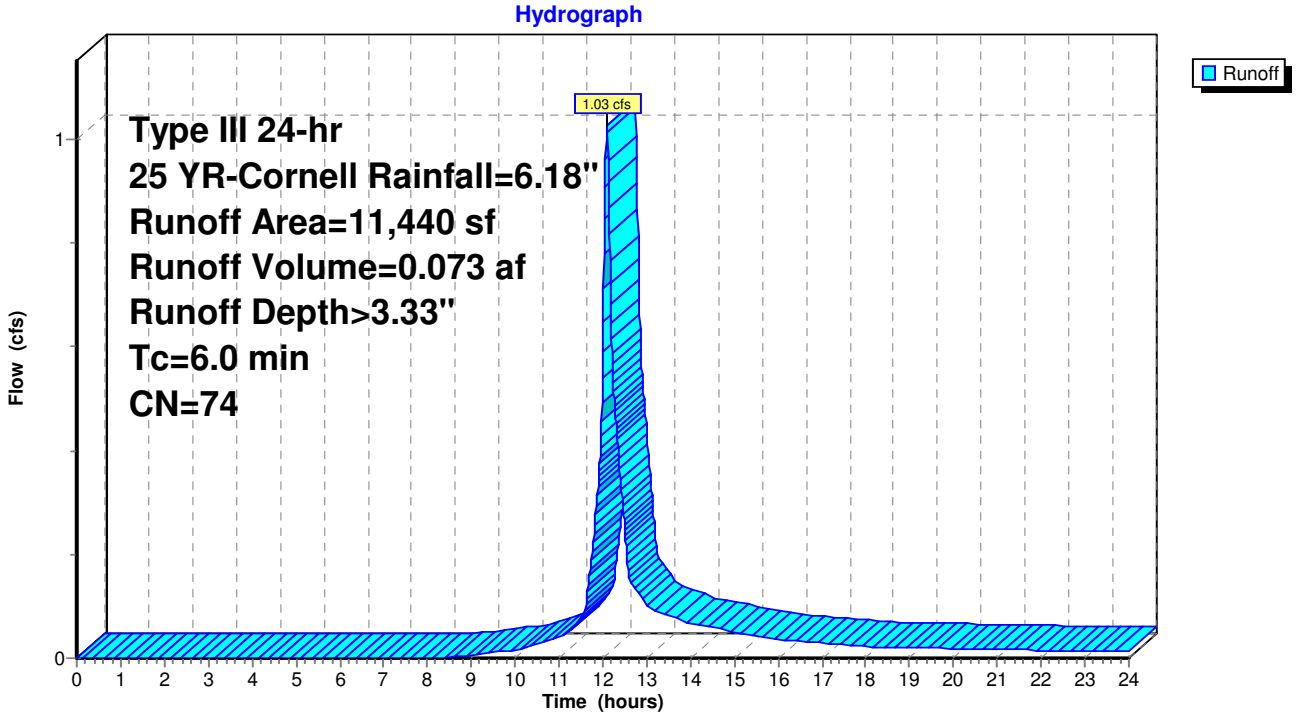
Runoff = 1.03 cfs @ 12.09 hrs, Volume= 0.073 af, Depth> 3.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YR-Cornell Rainfall=6.18"

Area (sf)	CN	Description
285	89	Gravel roads, HSG C
11,155	74	>75% Grass cover, Good, HSG C
11,440	74	Weighted Average
11,440		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Assume 6.0 Minutes-Min Tc**

Subcatchment POST 1A: Post Development Area 1A



Summary for Subcatchment POST 2: Post Development Area 2

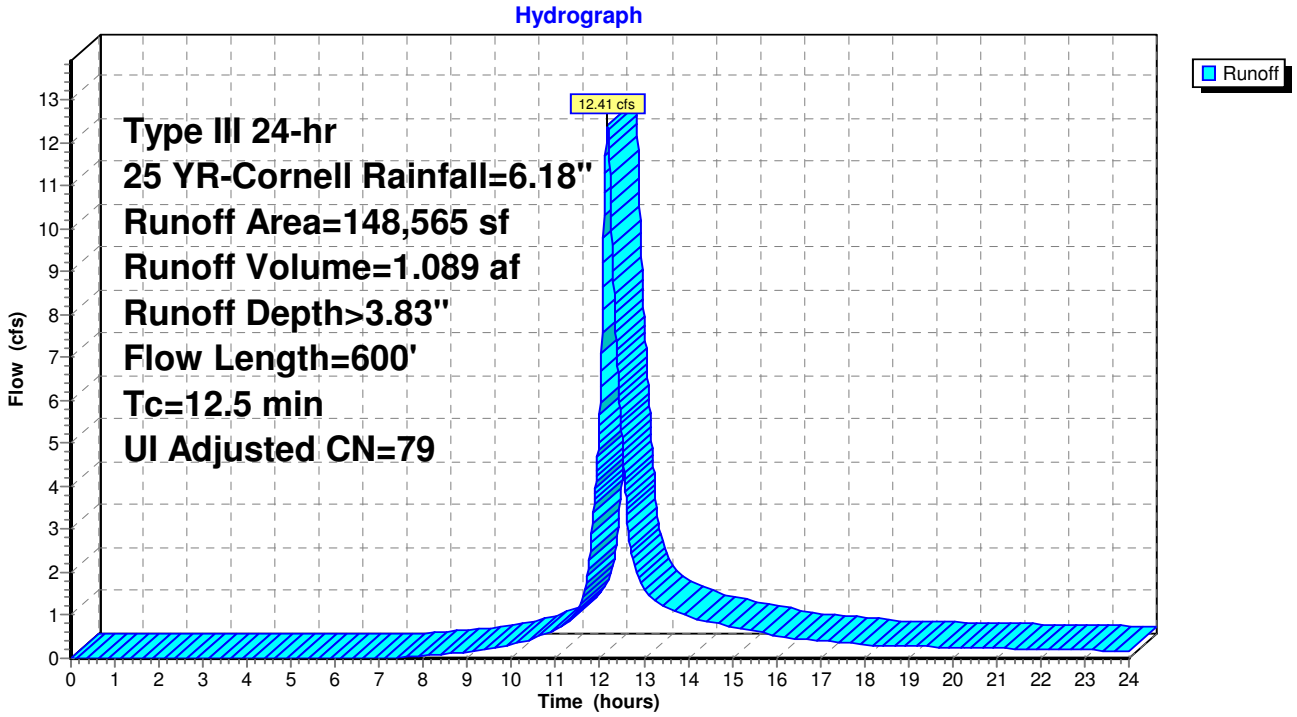
Runoff = 12.41 cfs @ 12.17 hrs, Volume= 1.089 af, Depth> 3.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YR-Cornell Rainfall=6.18"

	Area (sf)	CN	Adj	Description
	84,058	74		Pasture/grassland/range, Good, HSG C
*	41,571	98		Unconnected pavement, HSG C (Panels)
	16,786	89		Gravel roads, HSG C
	6,150	70		Woods, Good, HSG C
	148,565	82	79	Weighted Average, UI Adjusted
	106,994			72.02% Pervious Area
	41,571			27.98% Impervious Area
	41,571			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.9	350	0.0850	2.04		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.3	200	0.1400	12.95	4.52	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.5	600	Total			

Subcatchment POST 2: Post Development Area 2



Summary for Subcatchment POST 2A: Post Development Area 2A

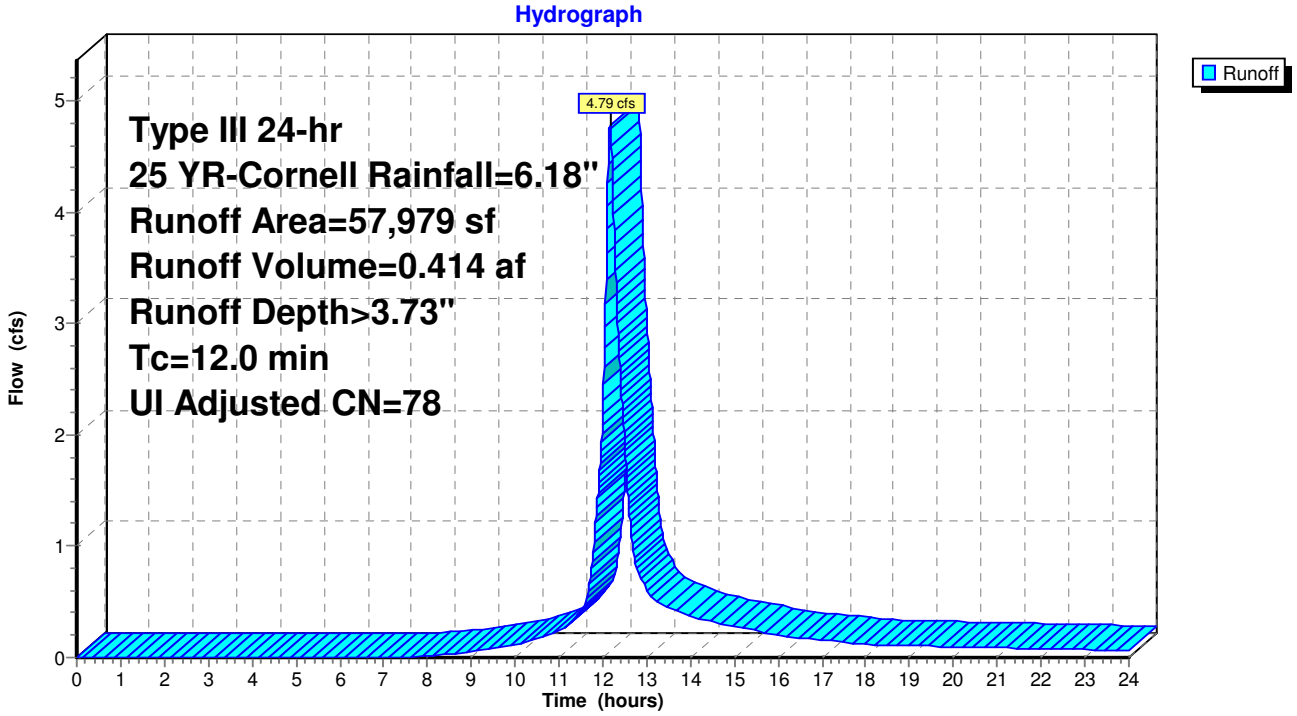
Runoff = 4.79 cfs @ 12.17 hrs, Volume= 0.414 af, Depth> 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YR-Cornell Rainfall=6.18"

Area (sf)	CN	Adj	Description
40,371	74		>75% Grass cover, Good, HSG C
16,539	98		Unconnected roofs, HSG C
1,069	89		Gravel roads, HSG C
57,979	81	78	Weighted Average, UI Adjusted
41,440			71.47% Pervious Area
16,539			28.53% Impervious Area
16,539			100.00% Unconnected

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

Subcatchment POST 2A: Post Development Area 2A



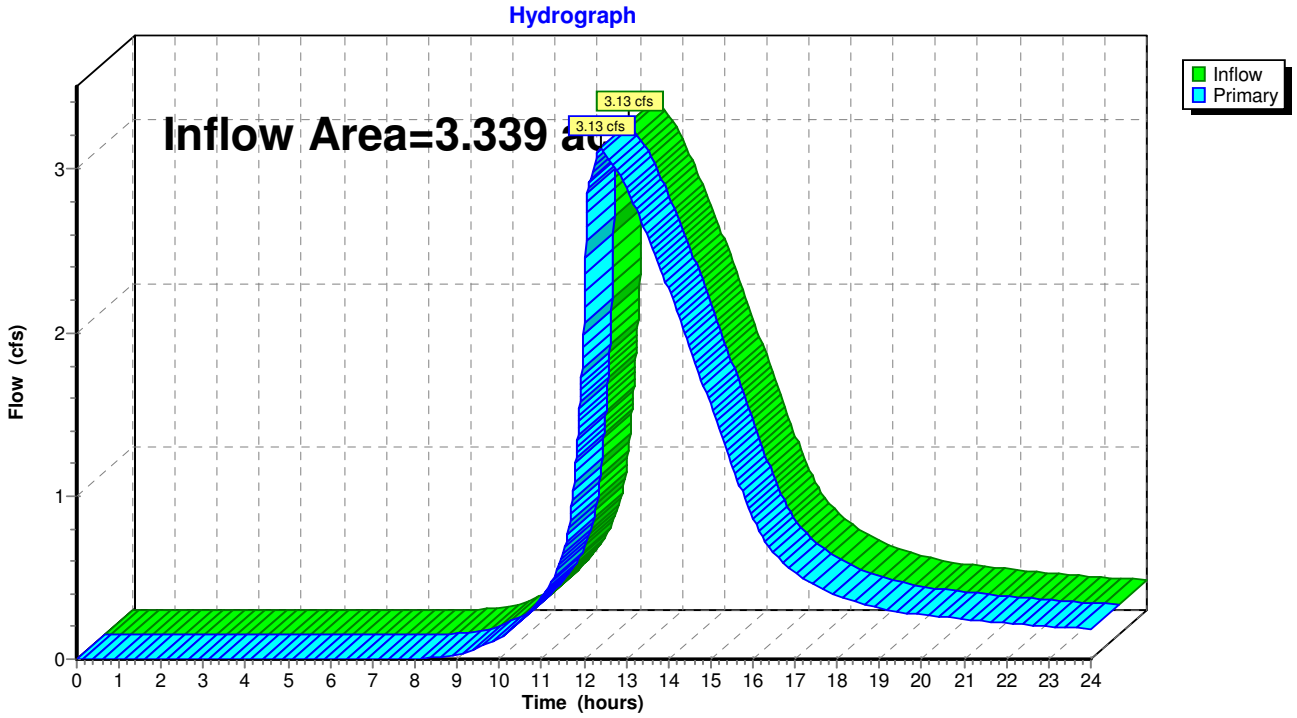
Summary for Pond AP-1: Westerly Property Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 3.339 ac, 23.93% Impervious, Inflow Depth > 3.70" for 25 YR-Cornell event
Inflow = 3.13 cfs @ 12.42 hrs, Volume= 1.030 af
Primary = 3.13 cfs @ 12.42 hrs, Volume= 1.030 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-1: Westerly Property Line



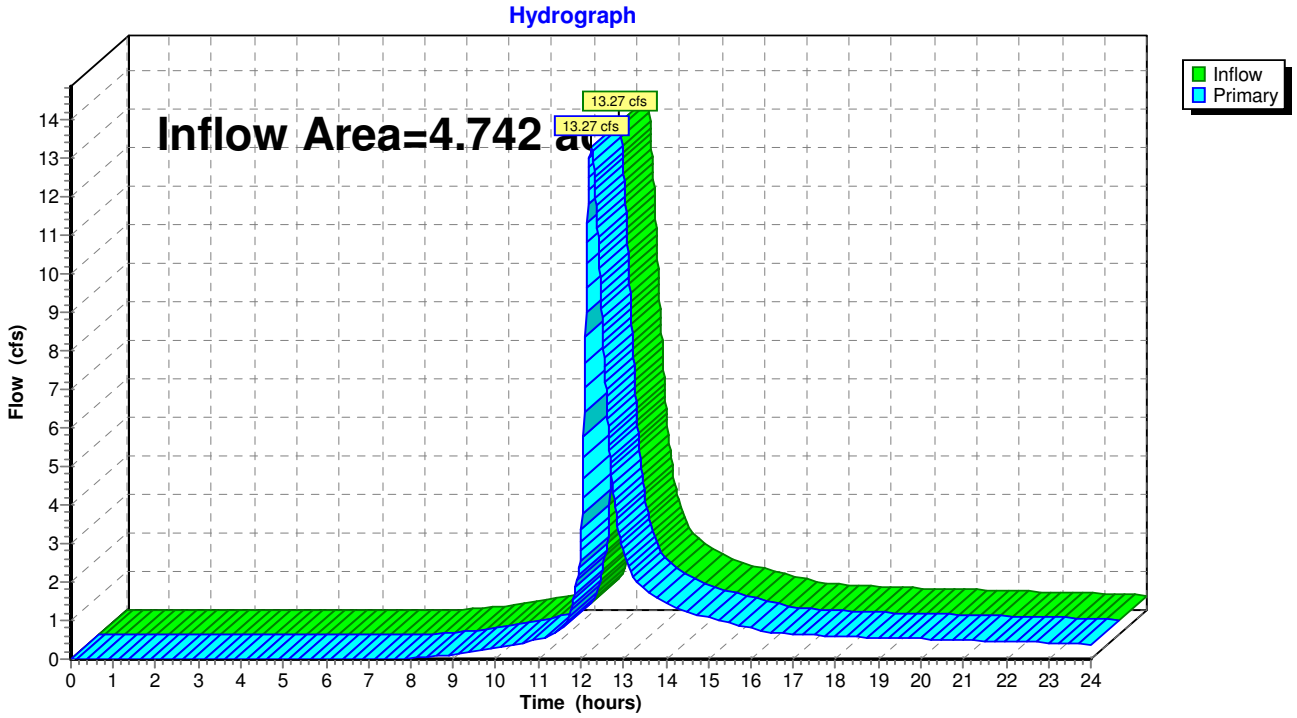
Summary for Pond AP-2: Easement Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 4.742 ac, 28.13% Impervious, Inflow Depth > 3.67" for 25 YR-Cornell event
Inflow = 13.27 cfs @ 12.25 hrs, Volume= 1.451 af
Primary = 13.27 cfs @ 12.25 hrs, Volume= 1.451 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-2: Easement Line



Summary for Pond East: Proposed Easterly Basin

Inflow Area = 3.411 ac, 27.98% Impervious, Inflow Depth > 3.83" for 25 YR-Cornell event
Inflow = 12.41 cfs @ 12.17 hrs, Volume= 1.089 af
Outflow = 9.48 cfs @ 12.28 hrs, Volume= 1.037 af, Atten= 24%, Lag= 6.7 min
Primary = 9.48 cfs @ 12.28 hrs, Volume= 1.037 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 188.29' @ 12.28 hrs Surf.Area= 6,723 sf Storage= 11,355 cf

Plug-Flow detention time= 91.3 min calculated for 1.037 af (95% of inflow)
Center-of-Mass det. time= 65.3 min (885.3 - 820.0)

Volume	Invert	Avail.Storage	Storage Description
#1	186.00'	24,433 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

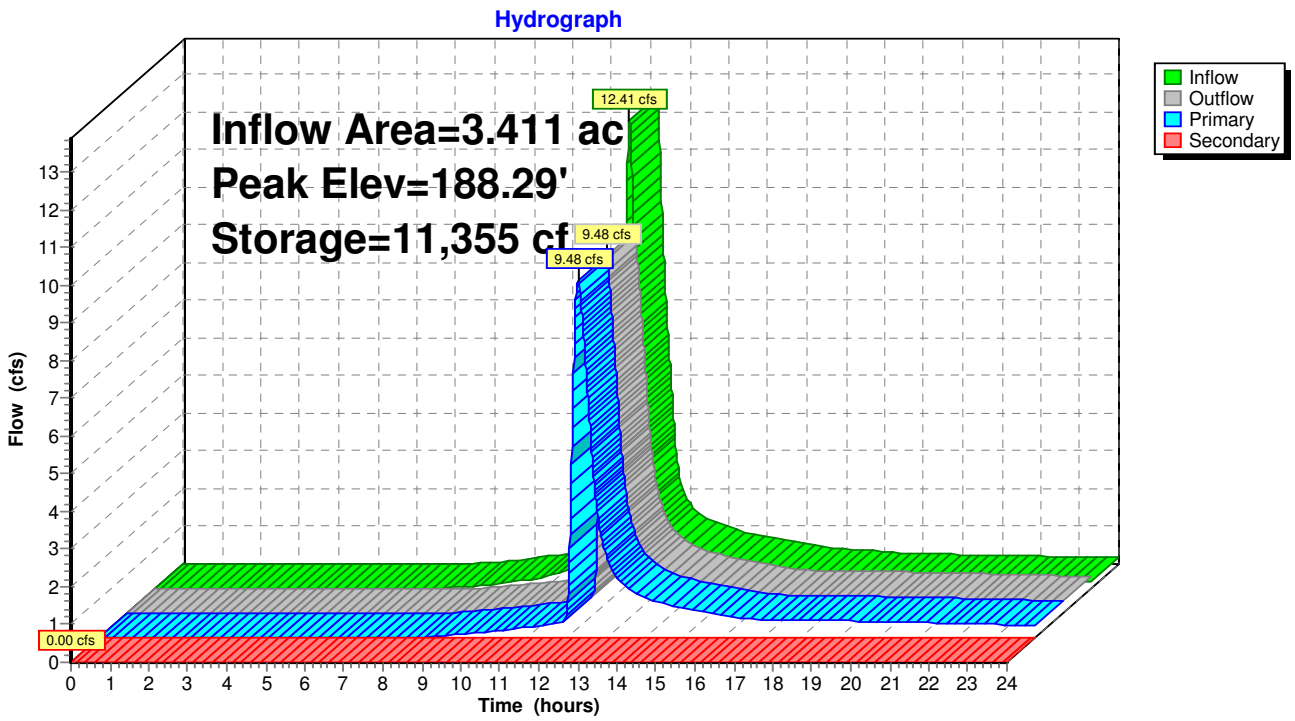
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
186.00	1,685	0	0
187.00	5,388	3,537	3,537
188.00	6,408	5,898	9,435
189.00	7,485	6,947	16,381
190.00	8,618	8,052	24,433

Device	Routing	Invert	Outlet Devices
#1	Primary	185.00'	**18.0" Round Culvert** L= 26.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 185.00' / 184.75' S= 0.0096 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.77 sf
#2	Device 1	186.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	187.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	189.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=9.47 cfs @ 12.28 hrs HW=188.29' (Free Discharge)
└─**1=Culvert** (Passes 9.47 cfs of 13.57 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.61 cfs @ 7.02 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Weir Controls 8.86 cfs @ 2.91 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=186.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond East: Proposed Easterly Basin



Summary for Pond West: Proposed Westerly Basin

Inflow Area = 3.076 ac, 25.97% Impervious, Inflow Depth > 3.83" for 25 YR-Cornell event
Inflow = 11.24 cfs @ 12.17 hrs, Volume= 0.982 af
Outflow = 2.90 cfs @ 12.63 hrs, Volume= 0.957 af, Atten= 74%, Lag= 27.5 min
Primary = 2.90 cfs @ 12.63 hrs, Volume= 0.957 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 163.23' @ 12.63 hrs Surf.Area= 8,753 sf Storage= 15,286 cf

Plug-Flow detention time= 73.2 min calculated for 0.957 af (97% of inflow)
Center-of-Mass det. time= 58.0 min (878.0 - 819.9)

Volume	Invert	Avail.Storage	Storage Description
#1	161.00'	33,550 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

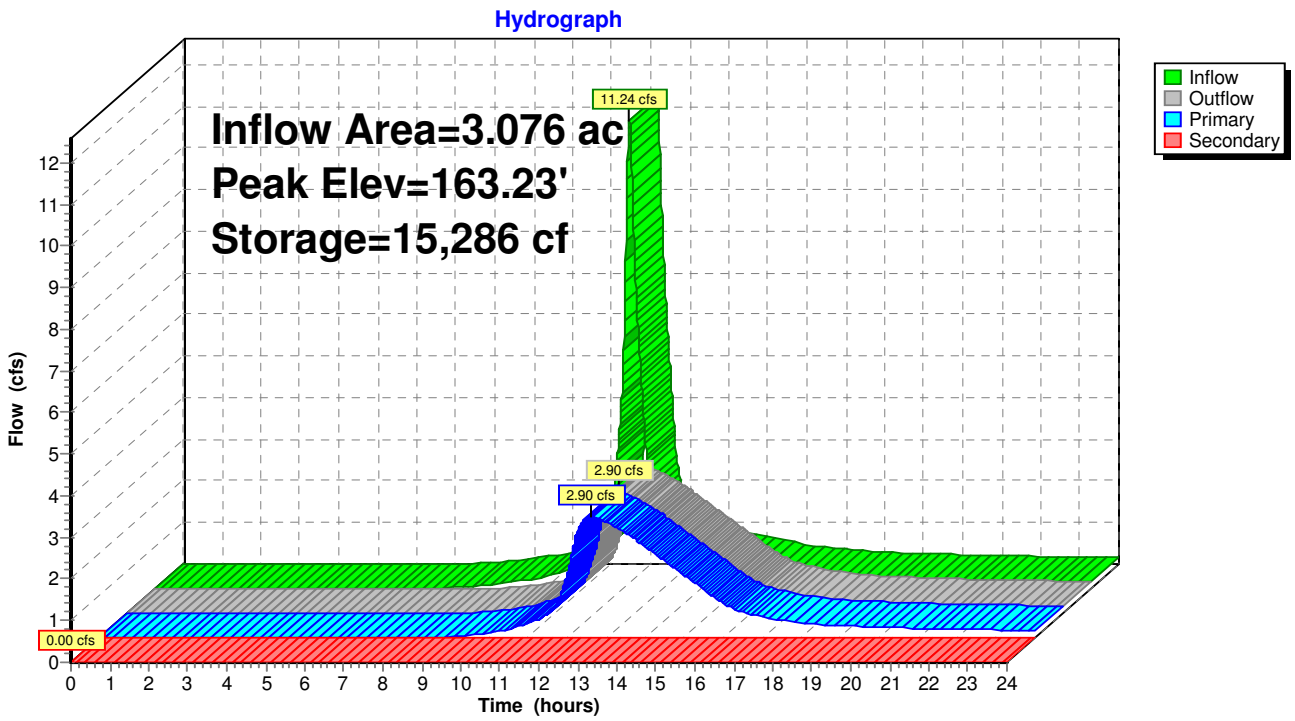
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
161.00	4,989	0	0
162.00	6,639	5,814	5,814
163.00	8,345	7,492	13,306
164.00	10,108	9,227	22,533
165.00	11,927	11,018	33,550

Device	Routing	Invert	Outlet Devices
#1	Primary	160.00'	**15.0" Round Culvert** L= 32.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 160.00' / 159.50' S= 0.0156 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.23 sf
#2	Device 1	161.00'	**9.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	163.35'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	164.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=2.90 cfs @ 12.63 hrs HW=163.23' (Free Discharge)
└─**1=Culvert** (Passes 2.90 cfs of 7.53 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 2.90 cfs @ 6.56 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=161.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond West: Proposed Westerly Basin



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 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 POST 1: Post Runoff Area=133,997 sf 25.97% Impervious Runoff Depth>6.28"
Flow Length=800' Tc=12.4 min UI Adjusted CN=79 Runoff=18.18 cfs 1.610 af

Subcatchment POST 1A: Post Development Runoff Area=11,440 sf 0.00% Impervious Runoff Depth>5.68"
Tc=6.0 min CN=74 Runoff=1.74 cfs 0.124 af

Subcatchment POST 2: Post Runoff Area=148,565 sf 27.98% Impervious Runoff Depth>6.28"
Flow Length=600' Tc=12.5 min UI Adjusted CN=79 Runoff=20.07 cfs 1.785 af

Subcatchment POST 2A: Post Runoff Area=57,979 sf 28.53% Impervious Runoff Depth>6.16"
Tc=12.0 min UI Adjusted CN=78 Runoff=7.81 cfs 0.683 af

Pond AP-1: Westerly Property Line Inflow=8.99 cfs 1.702 af
Primary=8.99 cfs 1.702 af

Pond AP-2: Easement Line Inflow=22.13 cfs 2.374 af
Primary=22.13 cfs 2.374 af

Pond East: Proposed Easterly Basin Peak Elev=188.78' Storage=14,753 cf Inflow=20.07 cfs 1.785 af
Primary=14.81 cfs 1.691 af Secondary=0.00 cfs 0.000 af Outflow=14.81 cfs 1.691 af

Pond West: Proposed Westerly Basin Peak Elev=163.92' Storage=21,733 cf Inflow=18.18 cfs 1.610 af
Primary=8.47 cfs 1.578 af Secondary=0.00 cfs 0.000 af Outflow=8.47 cfs 1.578 af

Total Runoff Area = 8.080 ac Runoff Volume = 4.203 af Average Runoff Depth = 6.24"
73.60% Pervious = 5.947 ac 26.40% Impervious = 2.133 ac

Summary for Subcatchment POST 1: Post Development Area 1

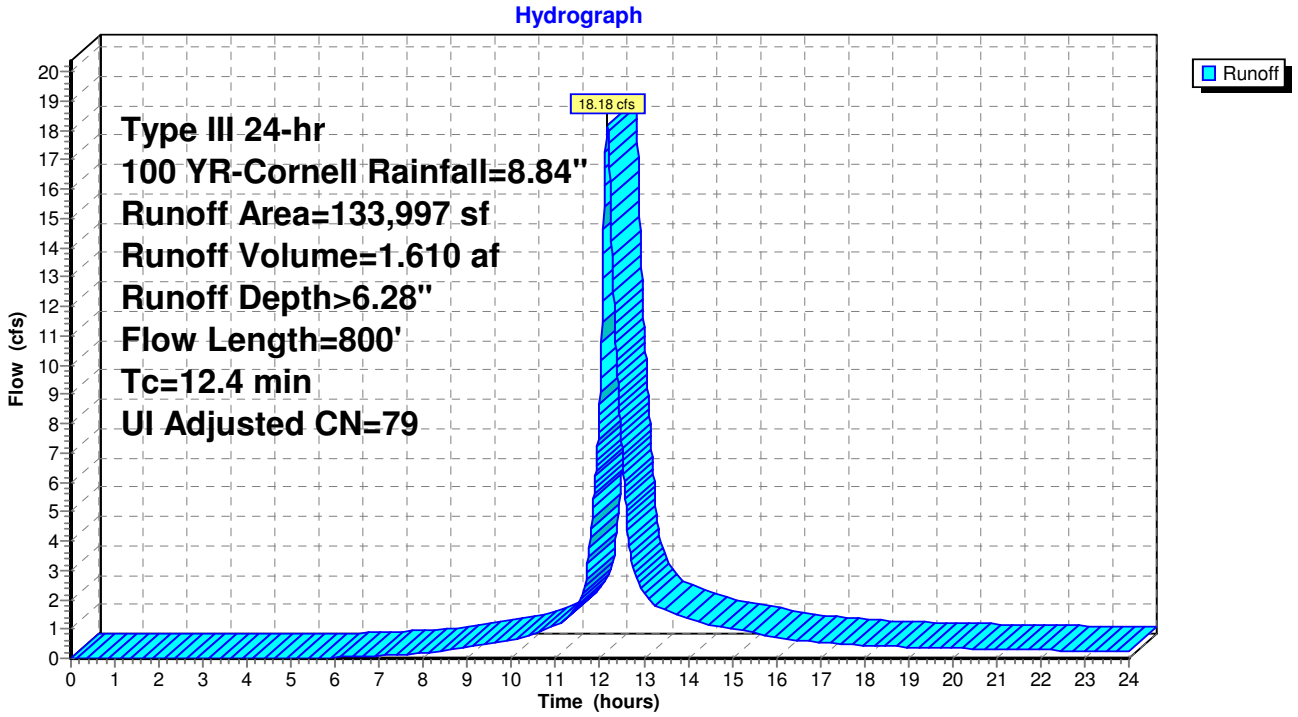
Runoff = 18.18 cfs @ 12.17 hrs, Volume= 1.610 af, Depth> 6.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YR-Cornell Rainfall=8.84"

	Area (sf)	CN	Adj	Description
	13,060	89		Gravel roads, HSG C
	8,168	72		Woods/grass comb., Good, HSG C
	77,969	74		Pasture/grassland/range, Good, HSG C
	33,972	98		Unconnected pavement, HSG C
*	828	98		Concrete Equipment Pads
	133,997	82	79	Weighted Average, UI Adjusted
	99,197			74.03% Pervious Area
	34,800			25.97% Impervious Area
	33,972			97.62% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.5	350	0.1100	2.32		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.6	400	0.1200	11.99	4.19	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.4	800	Total			

Subcatchment POST 1: Post Development Area 1



Summary for Subcatchment POST 1A: Post Development Area 1A

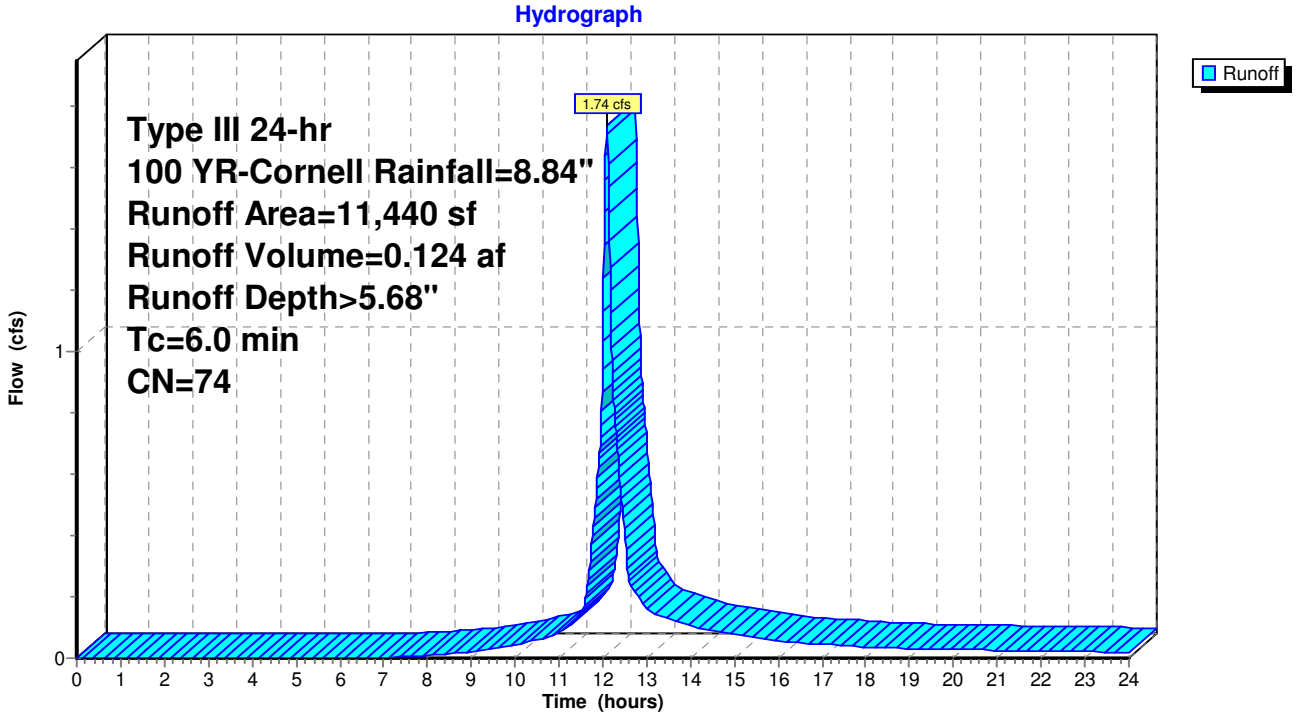
Runoff = 1.74 cfs @ 12.09 hrs, Volume= 0.124 af, Depth> 5.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YR-Cornell Rainfall=8.84"

Area (sf)	CN	Description
285	89	Gravel roads, HSG C
11,155	74	>75% Grass cover, Good, HSG C
11,440	74	Weighted Average
11,440		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, Assume 6.0 Minutes-Min Tc**

Subcatchment POST 1A: Post Development Area 1A



Summary for Subcatchment POST 2: Post Development Area 2

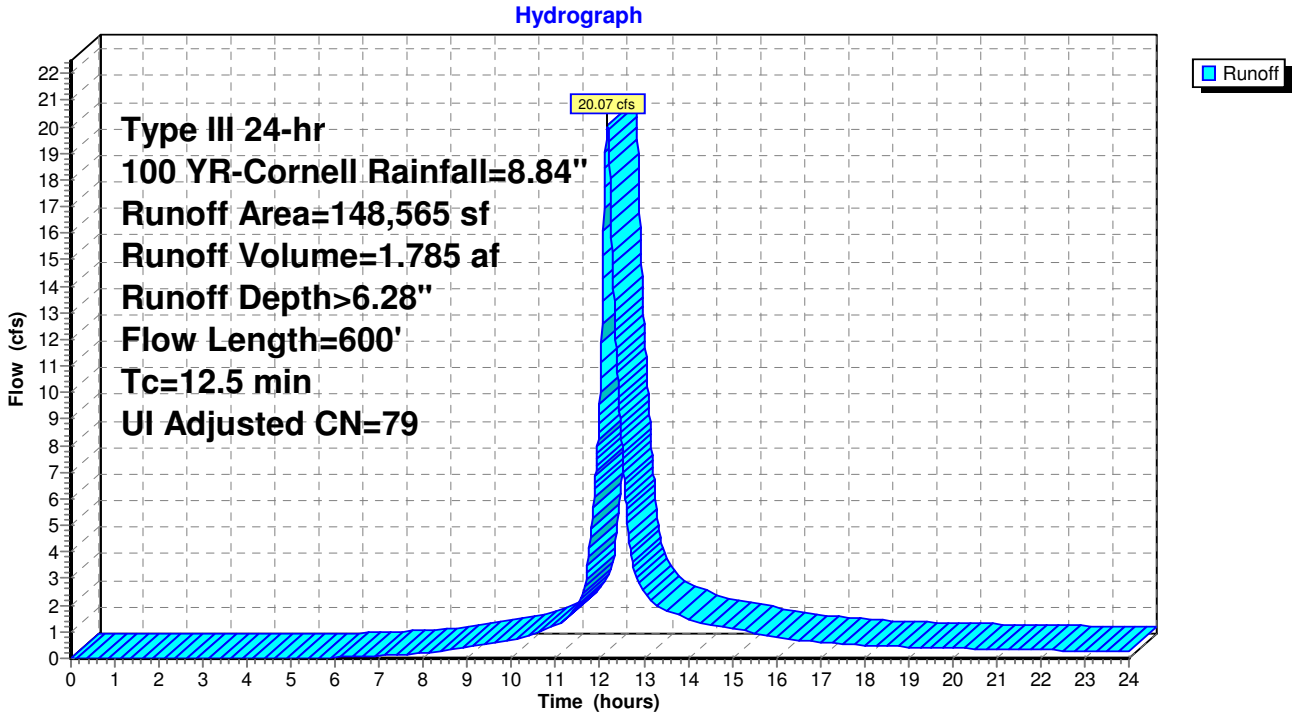
Runoff = 20.07 cfs @ 12.17 hrs, Volume= 1.785 af, Depth> 6.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YR-Cornell Rainfall=8.84"

	Area (sf)	CN	Adj	Description
	84,058	74		Pasture/grassland/range, Good, HSG C
*	41,571	98		Unconnected pavement, HSG C (Panels)
	16,786	89		Gravel roads, HSG C
	6,150	70		Woods, Good, HSG C
	148,565	82	79	Weighted Average, UI Adjusted
	106,994			72.02% Pervious Area
	41,571			27.98% Impervious Area
	41,571			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.24"
2.9	350	0.0850	2.04		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
0.3	200	0.1400	12.95	4.52	**Pipe Channel, C-D** 8.0" Round Area= 0.3 sf Perim= 2.1' r= 0.17' n= 0.013 Corrugated PE, smooth interior
12.5	600	Total			

Subcatchment POST 2: Post Development Area 2



Summary for Subcatchment POST 2A: Post Development Area 2A

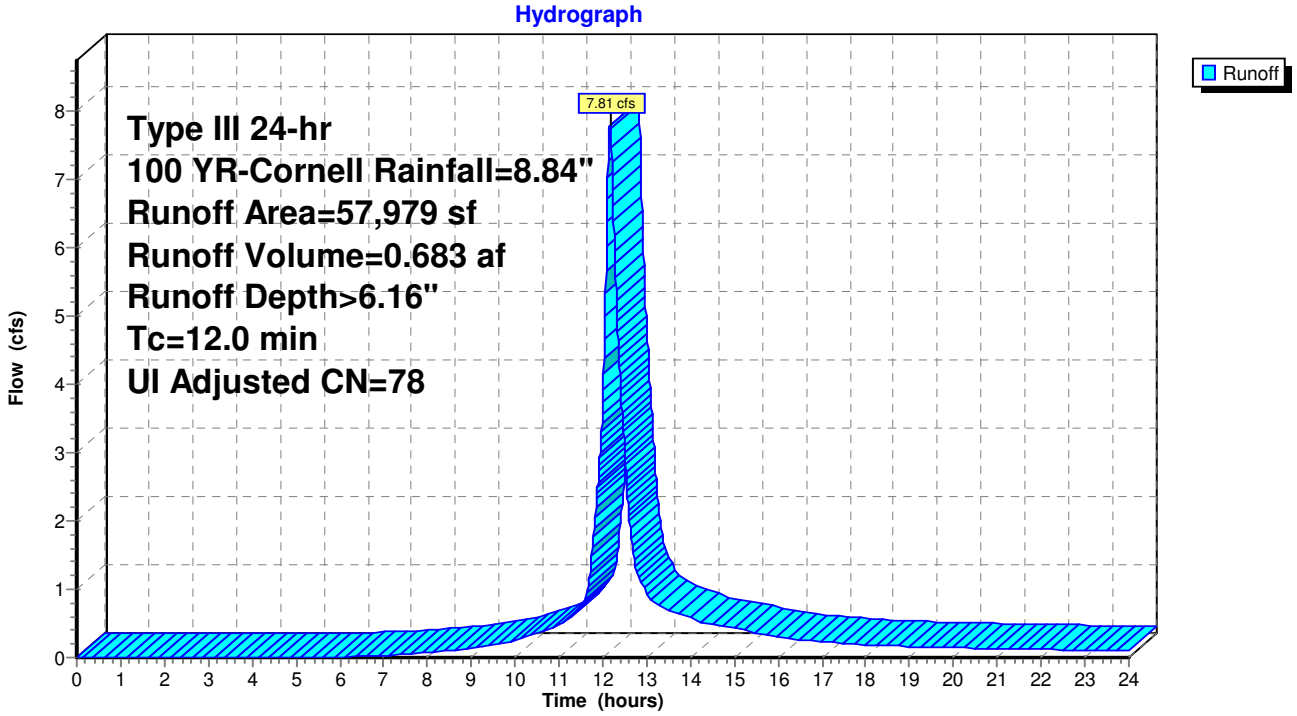
Runoff = 7.81 cfs @ 12.16 hrs, Volume= 0.683 af, Depth> 6.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YR-Cornell Rainfall=8.84"

Area (sf)	CN	Adj	Description
40,371	74		>75% Grass cover, Good, HSG C
16,539	98		Unconnected roofs, HSG C
1,069	89		Gravel roads, HSG C
57,979	81	78	Weighted Average, UI Adjusted
41,440			71.47% Pervious Area
16,539			28.53% Impervious Area
16,539			100.00% Unconnected

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

Subcatchment POST 2A: Post Development Area 2A



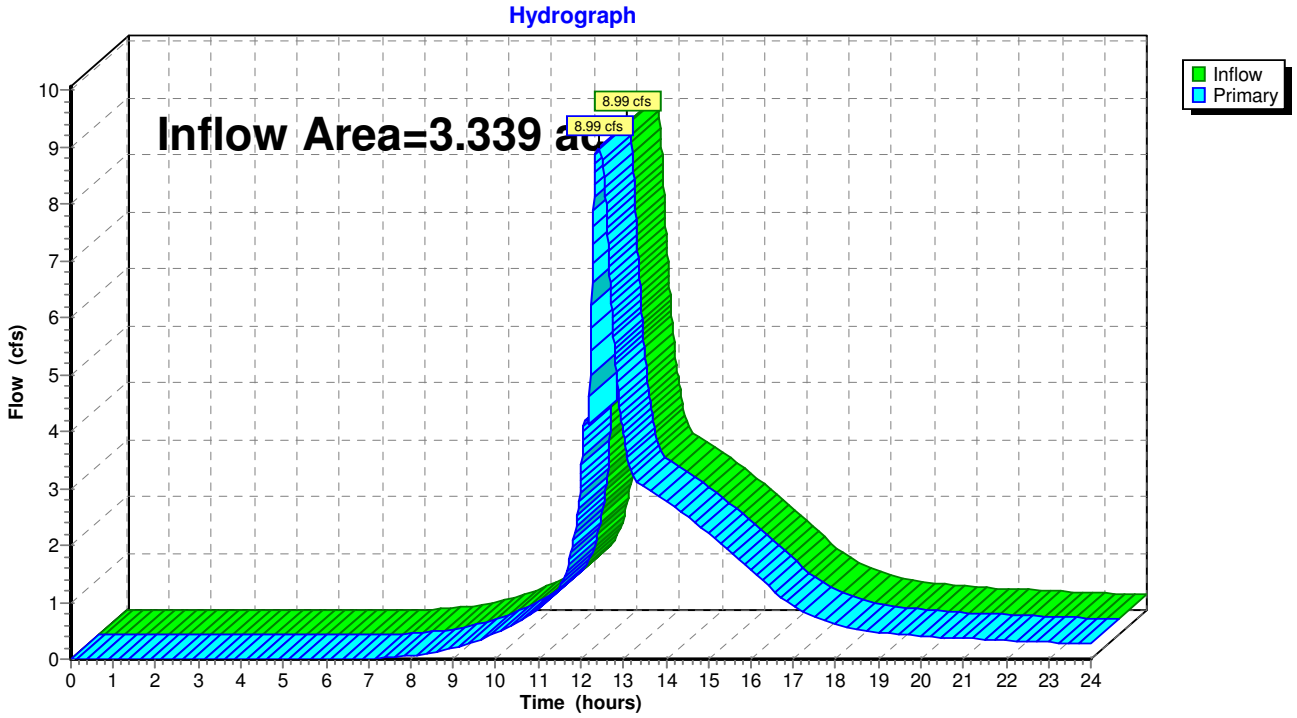
Summary for Pond AP-1: Westerly Property Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area =	3.339 ac,	23.93% Impervious,	Inflow Depth >	6.12"	for 100 YR-Cornell event
Inflow =	8.99 cfs @	12.41 hrs,	Volume=	1.702 af	
Primary =	8.99 cfs @	12.41 hrs,	Volume=	1.702 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-1: Westerly Property Line



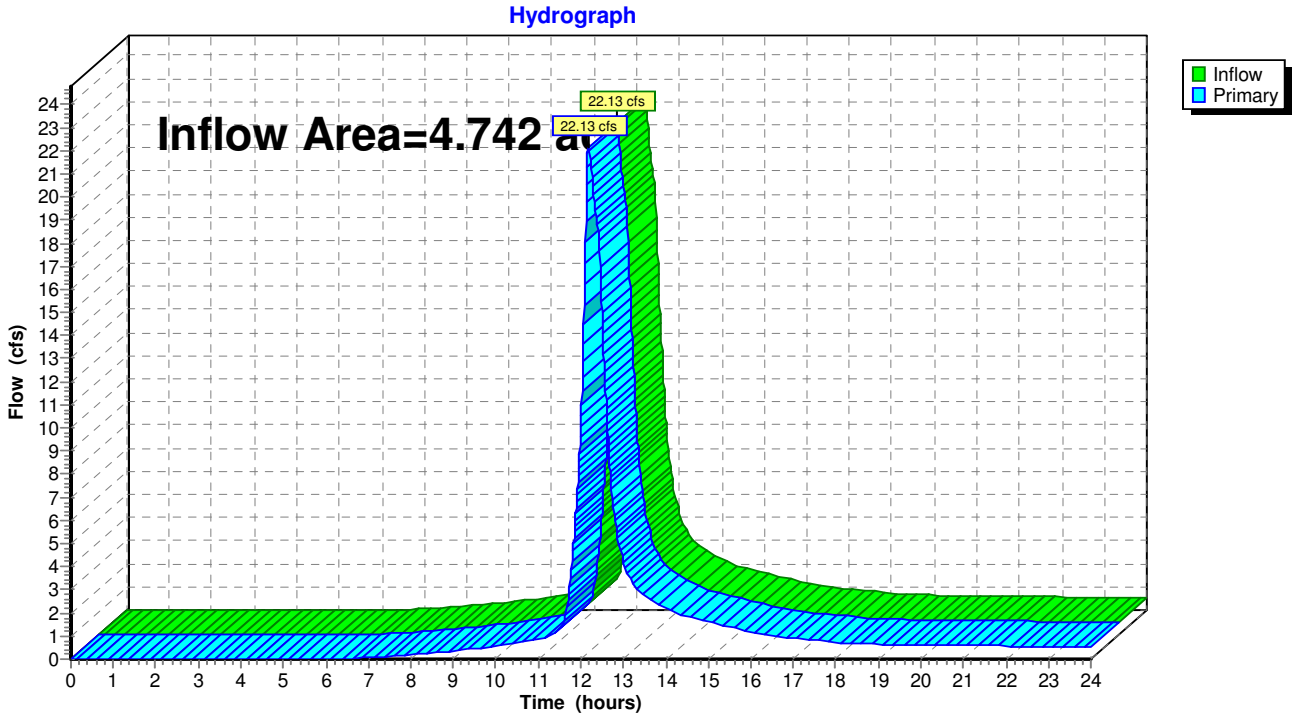
Summary for Pond AP-2: Easement Line

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 4.742 ac, 28.13% Impervious, Inflow Depth > 6.01" for 100 YR-Cornell event
Inflow = 22.13 cfs @ 12.18 hrs, Volume= 2.374 af
Primary = 22.13 cfs @ 12.18 hrs, Volume= 2.374 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Pond AP-2: Easement Line



Summary for Pond East: Proposed Easterly Basin

Inflow Area = 3.411 ac, 27.98% Impervious, Inflow Depth > 6.28" for 100 YR-Cornell event
Inflow = 20.07 cfs @ 12.17 hrs, Volume= 1.785 af
Outflow = 14.81 cfs @ 12.29 hrs, Volume= 1.691 af, Atten= 26%, Lag= 7.3 min
Primary = 14.81 cfs @ 12.29 hrs, Volume= 1.691 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 188.78' @ 12.29 hrs Surf.Area= 7,247 sf Storage= 14,753 cf

Plug-Flow detention time= 68.5 min calculated for 1.691 af (95% of inflow)
Center-of-Mass det. time= 39.7 min (845.8 - 806.1)

Volume	Invert	Avail.Storage	Storage Description
#1	186.00'	24,433 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

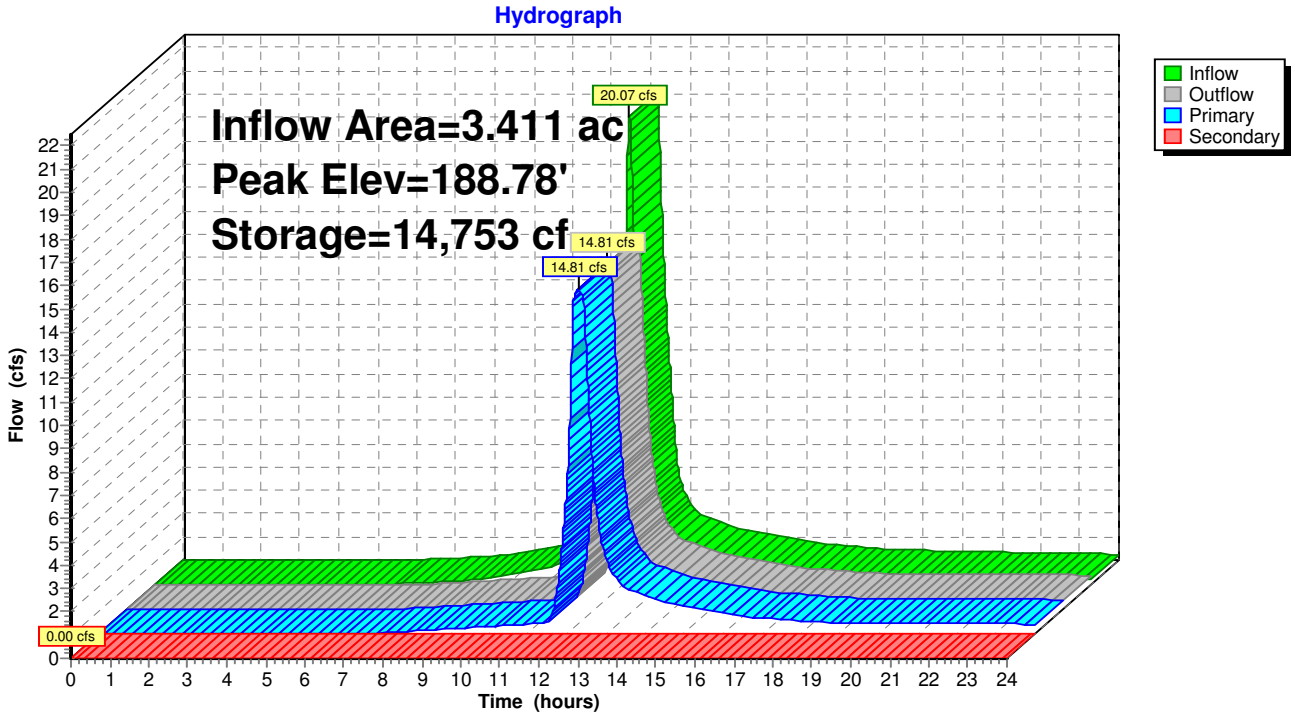
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
186.00	1,685	0	0
187.00	5,388	3,537	3,537
188.00	6,408	5,898	9,435
189.00	7,485	6,947	16,381
190.00	8,618	8,052	24,433

Device	Routing	Invert	Outlet Devices
#1	Primary	185.00'	**18.0" Round Culvert** L= 26.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 185.00' / 184.75' S= 0.0096 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.77 sf
#2	Device 1	186.00'	**4.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	187.50'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	189.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=14.81 cfs @ 12.29 hrs HW=188.78' (Free Discharge)
└─**1=Culvert** (Inlet Controls 14.81 cfs @ 8.38 fps)
  ├─**2=Orifice/Grate** (Passes < 0.68 cfs potential flow)
  └─**3=Sharp-Crested Rectangular Weir** (Passes < 17.71 cfs potential flow)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=186.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond East: Proposed Easterly Basin



Summary for Pond West: Proposed Westerly Basin

Inflow Area =	3.076 ac, 25.97% Impervious, Inflow Depth > 6.28" for 100 YR-Cornell event				
Inflow =	18.18 cfs @	12.17 hrs,	Volume=	1.610 af	
Outflow =	8.47 cfs @	12.45 hrs,	Volume=	1.578 af,	Atten= 53%, Lag= 16.7 min
Primary =	8.47 cfs @	12.45 hrs,	Volume=	1.578 af	
Secondary =	0.00 cfs @	0.00 hrs,	Volume=	0.000 af	

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs / 2
Peak Elev= 163.92' @ 12.45 hrs Surf.Area= 9,968 sf Storage= 21,733 cf

Plug-Flow detention time= 66.0 min calculated for 1.578 af (98% of inflow)
Center-of-Mass det. time= 54.2 min (860.2 - 806.0)

Volume	Invert	Avail.Storage	Storage Description
#1	161.00'	33,550 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

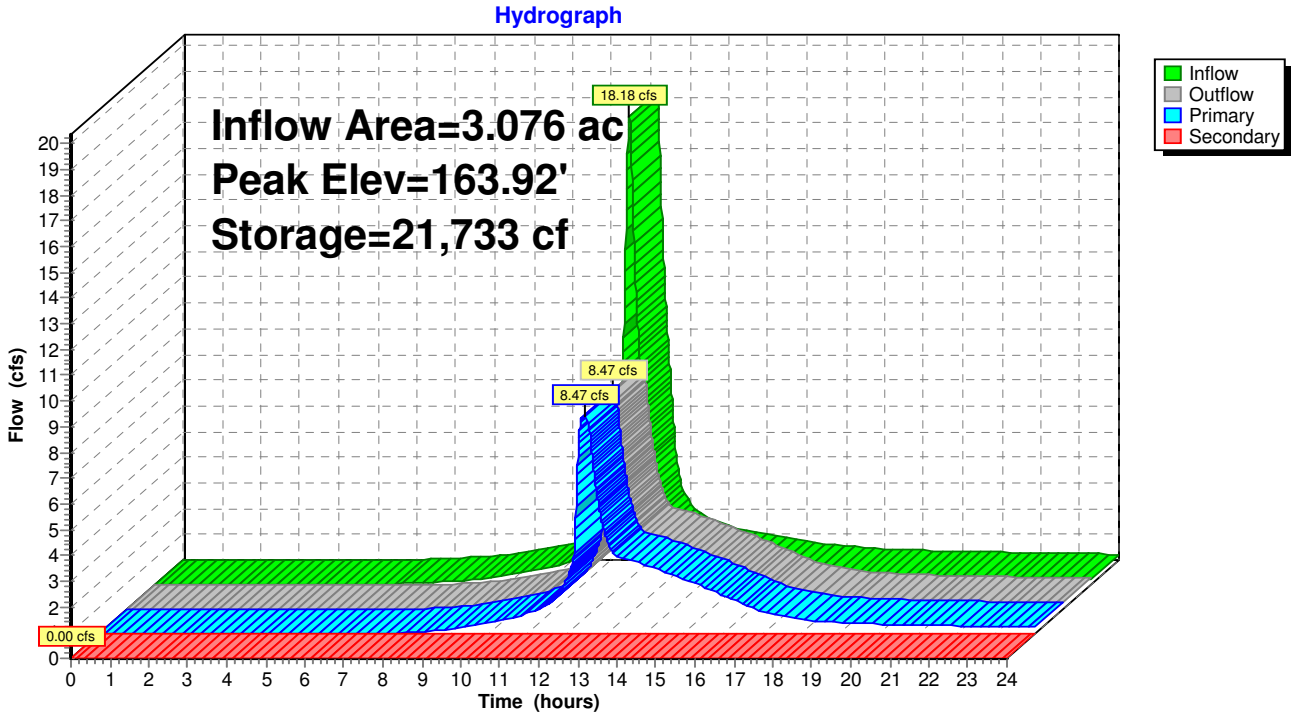
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
161.00	4,989	0	0
162.00	6,639	5,814	5,814
163.00	8,345	7,492	13,306
164.00	10,108	9,227	22,533
165.00	11,927	11,018	33,550

Device	Routing	Invert	Outlet Devices
#1	Primary	160.00'	**15.0" Round Culvert** L= 32.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 160.00' / 159.50' S= 0.0156 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.23 sf
#2	Device 1	161.00'	**9.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	163.35'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
#4	Secondary	164.00'	**15.0' long x 5.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

Primary OutFlow Max=8.47 cfs @ 12.45 hrs HW=163.92' (Free Discharge)
└─**1=Culvert** (Inlet Controls 8.47 cfs @ 6.90 fps)
  ├─**2=Orifice/Grate** (Passes < 3.39 cfs potential flow)
  └─**3=Sharp-Crested Rectangular Weir** (Passes < 5.47 cfs potential flow)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=161.00' (Free Discharge)
└─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond West: Proposed Westerly Basin



Section 3

Supplemental Data

FIELD ENGINEERING CO., INC.
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Taunton, MA 02780
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FAX (508) 824-9276

JOB 2035 GRAFTON
SHEET NO. 1 OF 2
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____
SCALE _____

Basin #1 Outfall Sizing - 100 YR STORM

$$Q_{Full} = \frac{0.463}{n} D^{8/3} S^{1/2} = \frac{0.463}{0.010}\left[\frac{15}{12}\right]^{8/3}\left[0.0156\right]^{1/2}$$

$S = 0.0156$
$D = 15''$

$$= (46.3)(1.81)(0.125)$$

$$\boxed{Q_{Full} = 10.5 \text{ CFS}}$$

$$V_{Full} = \frac{1.486}{n} R^{2/3} S^{1/2} = \frac{1.486}{0.010}\left[0.313\right]^{2/3}\left[0.0156\right]^{1/2}$$

$$R = \frac{\pi(7.5/12)^2}{2\pi\left(\frac{7.5}{12}\right)} = 0.313 \qquad = 148.6\,(0.46)\,(0.125)$$

$$\boxed{V_{Full} = 8.54 \text{ FT/SEC}}$$

$$\frac{Q}{Q_{Full}} = \frac{8.47}{10.5} = 0.81 \qquad \frac{d}{D} = 0.68$$

$Q = 8.47$ CFS (100 YR STORM)

$$\frac{V}{V_{Full}} = 1.12 \therefore V = 1.12\,(V_{Full})$$

$$\boxed{V = 9.56 \text{ FT/SEC}}$$

$$D_{50} = 0.20\,D\left[\frac{Q}{\sqrt{g}\,D^{2.5}}\right]^{4/3}\left(\frac{D}{T_w}\right) = 0.20(1.25)\left[\frac{8.47}{\sqrt{32.2}(1.25)^{2.5}}\right]\frac{1.25}{0.4(1.25)}$$

$$= 0.25\left(\frac{8.47}{9.91}\right)(2.5) = 0.53 \text{ FT}$$

$D_{50} = 0.53' \approx 6''$ Rip Rap Required
$\boxed{12'' \text{ Rip Rap Provided}}$

APRON LENGTH = $4D = 4(1.25) = 5.0'$
APRON DEPTH = $3.3\,(0.53') = 1.75'$
APRON WIDTH
@ END = $3D + 2/3\,L = 3(1.25) + 2/3(5) = 7.1'$

APRON SHOULD BE MIN 5.0' L / 1.75' DEEP / 7.1' WIDE @ END

FIELD ENGINEERING CO., INC.
Consulting Engineers

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JOB 2035 GRAFTON
SHEET NO. 2 OF 2
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____
SCALE _____

BASIN #2 OUTFALL SIZING - 100 YR STORM

$$Q_{full} = \frac{0.463}{n} D^{8/3} S^{1/2} = \frac{0.463}{0.010}\left[\frac{18}{12}\right]^{8/3}\left[0.0096\right]^{1/2}$$

$S = 0.0096$
$D = 18'$

$$= 46.3\,[2.95]\,[0.098]$$

$$\boxed{Q_{full} = 13.4 \text{ CFS}}$$

$$U_{full} = \frac{1.486}{n} R^{2/3} S^{1/2} = \frac{1.486}{0.010}\left[0.374\right]^{2/3}\left[0.0096\right]^{1/2}$$

$$R = \frac{\pi\left(\frac{9}{12}\right)^2}{2\pi\left(\frac{9}{12}\right)} = 0.374 \qquad U_{full} = 148.6\,[0.519]\,[0.098]$$

$$\boxed{U_{full} = 7.56 \text{ FT/SEC}}$$

$$\frac{Q}{Q_{full}} = \frac{14.81}{13.4} = 1.10 \qquad \frac{d}{D} = 0.94$$

$$\frac{V}{V_{full}} = 1.10 \therefore V = 1.10(7.56)$$

$Q = 14.81$ CFS (100 YR STORM)

$$\boxed{V = 8.32 \text{ FT/SEC}}$$

$$D_{50} = 0.200\left[\frac{Q}{\sqrt{g}\,D^{2.5}}\right]^{4/3}\left[\frac{D}{T_w}\right] = 0.20(1.5)\left[\frac{14.81}{\sqrt{32.2}(1.5)^{2.5}}\right]^{4/3}\frac{1.5}{0.4(1.5)}$$

$D_{50} = 0.71' \approx 9''$ RIPRAP Required
$\boxed{12'' \text{ RIPRAP PROVIDED}}$

APRON LENGTH = $4(1.5) = 6.0'$
APRON DEPTH = $3.3(0.71) = 2.3'$
APRON WIDTH @ END = $3D + 2/3\,L = 3(1.5) + 2/3(6) = 8.5'$

APRONS SHALL BE MIN 6.0' L
2.3' DEEP
8.5' W @ END

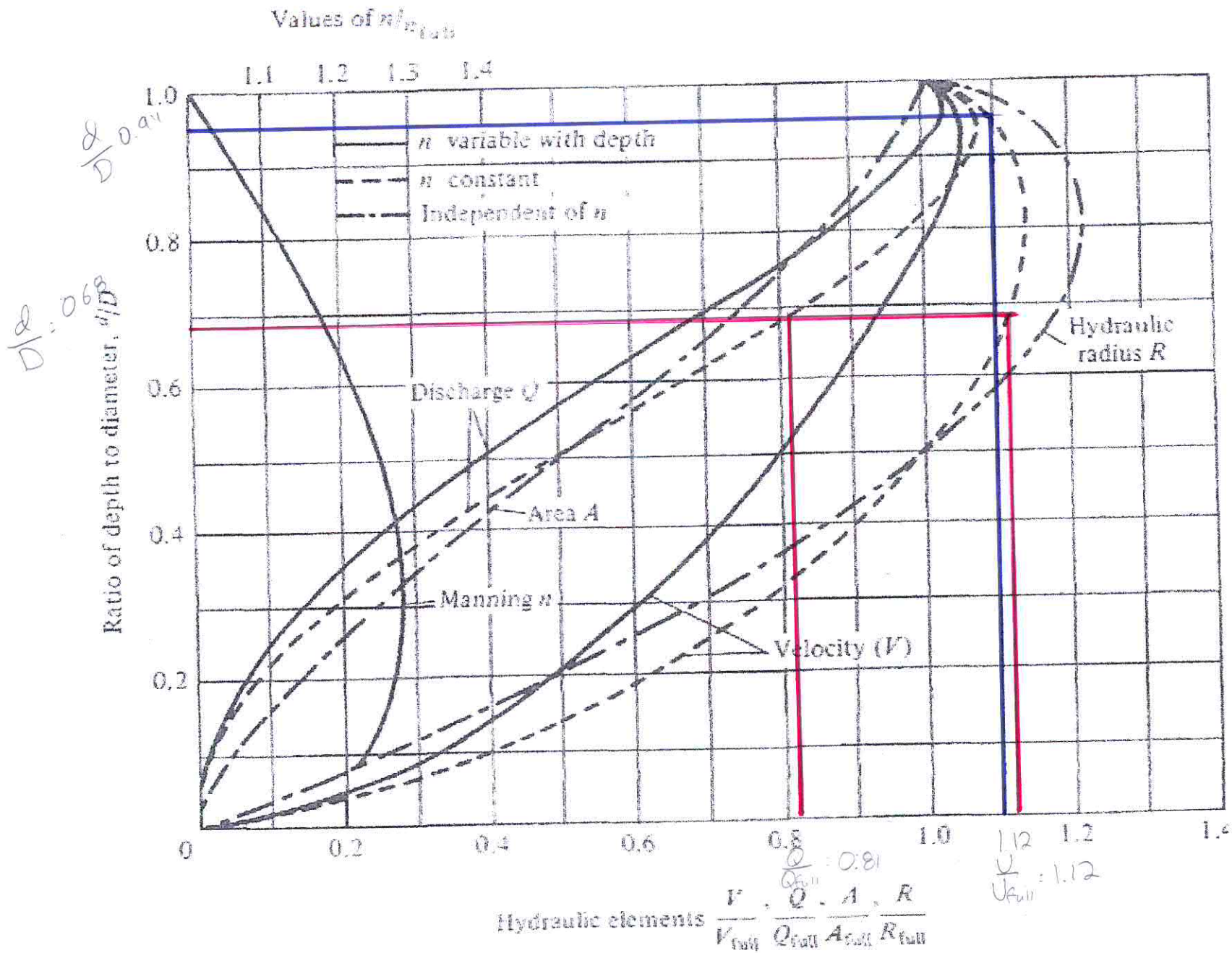

Figure 3. Hydraulic elements for circular pipes [2].

BASIN 1 BASIN 2

Location Address or Lot No. Rear of 207 Providence Road, Grafton

On-site Review

Deep Hole Number: TP#1 Date: 10/15/15 Time: 10:00 am Weather: Sunny, 65°F

Location (Identify on site plan): See site location plan-Detention Basin 2

Land Use: Vacant Residential Slope (%): 10% Surface Stones: Present

Vegetation: Woods

Landform:

Position on Landscape (sketch on the back): See site location plan

Distances from:

Open Water Body: >100 Feet Drainage way: >100 Feet

Possible Wet Area: >100 Feet Property Line: >10 Feet

Drinking Water Well: >100 Feet Other:

DEEP OBSERVATION HOLE LOG*

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0-9	O/A	Sandy Loam	10YR 3/2		Friable, Dry
9-24	B	Sandy Loam	10YR 4/6		Friable, Dry
24-84	C	Coarse Sandy Loam	2.5Y 5/4	@36"	Firm at Bottom 15-25% stones and cobbles.. Mottles: Faint high chroma

* MINIMUM OF 2 HOLES REQUIRED AT EVERY PROPOSED DISPOSAL AREA

Parent Material (geologic) Glacial Till Depth to Bedrock: N/E

Depth to Groundwater: Standing Water in the Hole N/E Weeping from Pit Face: N/E

Estimated Seasonal High Ground Water: 36" (Mottles)

Location Address or Lot No. Rear of 207 Providence Road, Grafton

On-site Review

Deep Hole Number: TP#2 Date: 10/15/15 Time: 10:00 am Weather: Sunny, 65°F

Location (Identify on site plan): See site location plan-Detention Basin 2

Land Use: Vacant Residential Slope (%): 10% Surface Stones: Present

Vegetation: Woods

Landform:

Position on Landscape (sketch on the back): See site location plan

Distances from:

Open Water Body: >100 Feet Drainage way: >100 Feet

Possible Wet Area: >100 Feet Property Line: >10 Feet

Drinking Water Well: >100 Feet Other:

DEEP OBSERVATION HOLE LOG*

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0-8	O/A	Sandy Loam	10YR 3/2		Friable, Dry
8-22	B	Sandy Loam	10YR 4/6		Friable, Dry
22-80	C	Sandy Loam	2.5Y 6/4	@40”	Firm at Bottom 15-25% stones and cobbles.. Mottles: Faint high chroma

* MINIMUM OF 2 HOLES REQUIRED AT EVERY PROPOSED DISPOSAL AREA

Parent Material (geologic) Glacial Till Depth to Bedrock: N/E

Depth to Groundwater: Standing Water in the Hole N/E Weeping from Pit Face: N/E

Estimated Seasonal High Ground Water: 40” (Mottles)

Location Address or Lot No. Rear of 207 Providence Road, Grafton

On-site Review

Deep Hole Number: TP#3 Date: 10/15/15 Time: 10:00 am Weather: Sunny, 65°F

Location (Identify on site plan): See site location plan-Detention Basin 1

Land Use: Vacant Residential Slope (%): 10% Surface Stones: Present

Vegetation: Woods

Landform:

Position on Landscape (sketch on the back): See site location plan

Distances from:

Open Water Body: >100 Feet Drainage way: >100 Feet

Possible Wet Area: >100 Feet Property Line: >10 Feet

Drinking Water Well: >100 Feet Other:

DEEP OBSERVATION HOLE LOG*

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0-8	O/A	Sandy Loam	10YR 3/2		Friable, Dry
8-30	B_w	Sandy Loam	10YR 4/6		Friable, Dry
30-56	C	Sandy Loam	2.5Y 6/4	@40”	Firm at Bottom 20-30% stones and cobbles.Boulders at bottom-no refusal. Mottles: Faint high chroma

* MINIMUM OF 2 HOLES REQUIRED AT EVERY PROPOSED DISPOSAL AREA

Parent Material (geologic) Glacial Till Depth to Bedrock: N/E

Depth to Groundwater: Standing Water in the Hole N/E Weeping from Pit Face: N/E

Estimated Seasonal High Ground Water: 36” (Mottles)

Location Address or Lot No. Rear of 207 Providence Road, Grafton

On-site Review

Deep Hole Number: TP#4 Date: 10/15/15 Time: 10:00 am Weather: Sunny, 65°F

Location (Identify on site plan): See site location plan-Detention Basin 1

Land Use: Vacant Residential Slope (%): 10% Surface Stones: Present

Vegetation: Woods

Landform:

Position on Landscape (sketch on the back): See site location plan

Distances from:

Open Water Body: >100 Feet Drainage way: >100 Feet

Possible Wet Area: >100 Feet Property Line: >10 Feet

Drinking Water Well: >100 Feet Other:

DEEP OBSERVATION HOLE LOG*

Depth from Surface (Inches)	Soil Horizon	Soil Texture (USDA)	Soil Color (Munsell)	Soil Mottling	Other (Structure, Stones, Boulders, Consistency, % Gravel)
0-7	O/A	Sandy Loam	10YR 3/2		Friable, Dry
7-33	B_w	Sandy Loam	10YR 4/6		Friable, Dry
33-60	C	Sandy Loam	2.5Y 6/4	@34”	Firm at Bottom 20-30% stones and cobbles.Boulders @ 40”-no refusal. Mottles: Faint high chroma

* MINIMUM OF 2 HOLES REQUIRED AT EVERY PROPOSED DISPOSAL AREA

Parent Material (geologic) Glacial Till Depth to Bedrock: N/E

Depth to Groundwater: Standing Water in the Hole N/E Weeping from Pit Face: N/E

Estimated Seasonal High Ground Water: 34” (Mottles)

Appendix A

Revised Post Development Watershed Plan