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January 8, 2010

Maya van Rossum  
The Riverkeeper  
Delaware Riverkeeper Network  
300 Pond Street, Second Floor  
Bristol, PA 19007

RE: Hamilton Estates  
Block 2732 Lots 7.01 and 7.03  
Hamilton Township, Mercer County, NJ

Dear Ms. van Rossum,

As you requested, I have reviewed the stormwater management system for the development of Block 2732, Lots 7.01 and 7.03 in Hamilton Township, Mercer County, New Jersey, otherwise known as Hamilton Estates. My analysis focused upon the project's compliance with the New Jersey Stormwater Rule at N.J.A.C. 7:8 (Rule) and Hamilton Township Stormwater Control Ordinance 158 (Ordinance).

I utilized the following documents for this review:

"Drainage Study for Hamilton Estates, Block 2732, Lot 7.01 Township of Hamilton, Mercer County, NJ" dated August 2006 and prepared by Challoner & Magno Engineering, LLC.

"Stormwater Maintenance Report for Hamilton Estates, Block 2732, Lots 7.01 and 7.03, Township of Hamilton, Mercer County, NJ" dated June 2006 and prepared by Challoner and Magno Engineering, LLC.

"Hamilton Estates, Preliminary and Final Major Subdivision for Block 2732, Lots 7.01 & 7.02 Situated in the Township of Hamilton, Mercer County, New Jersey" dated July 12, 2004 and revised to August 28, 2006, prepared by Challoner and Magno Engineering, LLC. Sheets 1 through 10, 22 and 24.

## Overview of Development Project

The Hamilton Estates development project consists of 12 single family residential units proposed to be constructed on a 63.5 acre agricultural tract bordered by Yardville Allentown Road to the north, Tattletown Road to the east, and Doctor's Creek to the south. From Yardville Allentown Road, the site slopes gently downward toward its southern boundary with Doctor's Creek. The site contains a finger of wetlands roughly 100 feet wide that begins on the northwestern portion of the site and extends southward approximately 800 feet to the point where it connects to a ditch that carries drainage flows to an onsite pond. This pond also receives a large portion of the runoff flows from the eastern portion of the property. The pond is fitted with a 30" standpipe that drains into a scour hole and then into the wetlands area that is adjacent to Doctor's Creek.

The development consists of 6 residential units located near Yardville Allentown Road, one unit fronting Tattletown Road and 5 units located along a cul-de-sac that runs along the western edge of the site. Thus, much of the site disturbance is limited to the perimeter portions of the tract and a large portion of the interior is undisturbed. The developed areas are underlain by Hydrological Soil Group (HSG) B and C soils. The undisturbed interior area contains the majority of the site's HSG A soils. Much of the runoff will be conveyed to a detention basin that is fitted with a Manufactured Treatment Device. The outfall structure directs the basin's flows to the existing onsite pond.

## Stormwater Management Technical Review

The Hamilton Estates stormwater management measures do not meet the following portions of the Rule (in boldface) and Ordinance (in brackets):

**7:8-5.6 Calculation of stormwater runoff and groundwater recharge** [158-5. (a)]

**7:8-5.7 Standards for structural stormwater management measures** [158-6. (a)]

This technical review is presented in the following format:

The Rule will be cited as underlined with text in *italics* and my comment in **bold preceded by a Capital Letter**. The citation for the Hamilton Township Ordinance will be in brackets [Chapter.subchapter] following the N.J.A.C. 7:8 citation.

7:8-5.3 Nonstructural stormwater management strategies [158-4. (e)]

*(a) To the maximum extent practicable, the standards in N.J.A.C. 7:8-5.4 and 5.5 shall be met by incorporating nonstructural stormwater management strategies at N.J.A.C. 7:8- 5.3 into the design. The persons submitting an application for review shall identify the nonstructural strategies incorporated into the design of the project. If the applicant contends that it is not feasible for engineering, environmental, or safety reasons to incorporate any nonstructural stormwater management strategies identified in (b) below into the design of a particular project, the applicant shall identify the strategy and provide a basis for the contention.*

**A. The applicant has provided a description of the nonstructural stormwater strategies being utilized on the site. In addition, the applicant has evaluated the sufficiency of the nonstructural stormwater strategies using the NJDEP's Nonstructural Stormwater Strategies Point System spreadsheet. Since the site is in a Planning Area 4, it is required to achieve 104% of the existing points in the post-developed condition. The project has achieved 153% of the points after development. This project is an excellent example of implementing nonstructural stormwater strategies prior to a consideration of structural strategies. The existing grades and hydrologic behavior of the site are maintained to a great degree and soil compaction is limited. The development limits disturbance on the site and protects the areas that provide the greatest water quality benefits, i.e. the areas underlain by HSG A soils and nearly all of the wetlands and wetlands transition areas.**

7:8-5.4 Erosion control, groundwater recharge and runoff quantity standards [158-4. (f)]

*(a) 2. The minimum design and performance standards for groundwater recharge are as follows:*

*i. The design engineer shall, using the assumptions and factors for stormwater runoff and groundwater recharge calculations at N.J.A.C. 7:8-5.6, either:*

*(1) Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent of the average annual pre- construction groundwater recharge volume for the site; or*

**B. The applicant performed the NJDEP's Groundwater Recharge Spreadsheet Analysis to determine the recharge impacts from this development. The spreadsheet indicates that there will be a recharge surplus with this development. According to the spreadsheet analysis, agricultural uses have a much greater runoff potential than grassy lawn areas. This differential is large enough that it negates the impact of the increase in impervious cover on the site. Thus, the groundwater recharge requirement of the Rule and the Ordinance has been met.**

*(a) 3 iii. Design stormwater management measures so that the post-construction peak runoff rates for the two, 10 and 100-year storm events are 50, 75 and 80 percent, respectively, of the pre-construction peak runoff rates.*

**C. The design engineer made several incorrect assumptions in the hydrological analysis that may have resulted in incorrect peak flow calculations. As will be discussed in Paragraphs E through H below, these assumptions were as follows:**

- 1. The NRCS methodology was used and this would have required the use of the DelMarva dimensionless unit hydrograph.**
- 2. The hydrologic analysis did not account for the brushy areas of the site in the existing condition.**

3. The analysis did not route the pervious and impervious areas separately for all developed portions of the site.
4. Inaccurate Hydrological Soil Groups were utilized in the analysis.

I have performed a revised hydrological analysis using HydroCAD 9.0. I have utilized the DelMarva dimensionless unit hydrograph and have routed the pervious and impervious areas separately. My analysis indicates that the project will still easily meet the peak flow reductions for all storm events. The analysis is included in Attachment A. The revised flows can be found in Table 1.

**TABLE 1**  
**REVISED RUNOFF CALCULATIONS**  
**(Routing Pervious & Impervious Areas Separately, DelMarva Unit Hydrograph)**  
**Peak Flows (CFS)**

	<u>2 Yr Storm</u>	<u>10 Yr Storm</u>	<u>100 Yr Storm</u>
Existing Runoff (cfs)	17.4	42.86	101.12
Reduction Percentage	50%	75%	80%
Target Discharge (cfs)	8.7	32.1	80.9
Proposed Site Discharge (cfs)	5.69	19.8	61.08
Reduction Requirement Met	YES	YES	YES

It is beyond the scope of this report to remodel the system using the corrected HSGs. It is also not possible to determine which land cover the developer used *instead* of the brush land use in the existing condition. However, as will be discussed below, it is likely that the peak flow reductions would still be met if the analysis modeled the proper HSG areas and accounted for the brushy areas.

7:8-5.5 Stormwater runoff quality standards [158-4. (g)]

*Stormwater management measures shall be designed to reduce the post-construction load of total suspended solids (TSS) in stormwater runoff generated from the water quality design storm by 80 percent of the anticipated load from the developed site, expressed as an annual average. Stormwater management measures shall only be required for water quality control if an additional one-quarter acre of impervious surface is being proposed on a development site. The requirement to reduce TSS does not apply to any stormwater runoff in a discharge regulated under a numeric effluent limitation for TSS imposed under the New Jersey Pollutant Discharge Elimination System (NJPDES) rules, N.J.A.C. 7:14A, or in a discharge specifically exempt under a NJPDES permit from this requirement. The water quality design storm is 1.25 inches of rainfall in two hours. Water quality calculations shall take into account the distribution of rain from the water quality design storm, as reflected in Table 1 below. The*

*calculation of the volume of runoff may take into account the implementation of non-structural and structural stormwater management measures.*

*(d) If there is more than one onsite drainage area, the 80 percent TSS removal rate shall apply to each drainage area, unless the runoff from the subareas converge on site in which case the removal rate can be demonstrated through a calculation using a weighted average.*

**D. The stormwater management plan proposes to provide an extended detention basin and a Manufactured Treatment Device (Stormfilter) to treat the routed runoff flows. The outlet structure is designed such that the flows from storm events larger than the water quality storm bypass the Stormfilter.**

**A review of the water quality hydrograph routing and the basin storage table data indicates that greater than 10% of the maximum water quality storm volume will remain in the basin after 24 hours. Therefore, the detention basin achieves a TSS removal rate of 60%. When this treatment is combined with the Stormtech device, this BMP series would result in a 92% TSS removal rate for the routed flows.**

**There are, additionally, 3 driveways whose runoff flows overland to the onsite pond. The outfall from the detention basin also is conveyed to this pond. Thus, all of the runoff converges at one point on the site and a weighted TSS removal rate can be applied to the routed and overland flows to determine the total TSS removal for the site. The weighted TSS removal rate was accurately calculated by the engineer to be 81.8%. Therefore this project meets the requirements of this section of the Rule and the Ordinance.**

*7:8-5.6 Calculation of stormwater runoff and groundwater recharge [158-5. (a)]*

*(a) Stormwater runoff shall be calculated in accordance with the following:*

*1. The design engineer shall calculate runoff using one of the following methods:*

*i. The USDA Natural Resources Conservation Service (NRCS) methodology, including the NRCS Runoff Equation and Dimensionless Unit Hydrograph, as described in Section 4, National Engineering Handbook (NEH-4), dated July 2002, incorporated herein by reference as amended and supplemented. This methodology is additionally described in Technical Release 55 - Urban Hydrology for Small Watersheds (TR-55), dated June 1986, incorporated herein by reference as amended and supplemented.*

**E. The engineer has performed the hydrological calculations using the NRCS methodology. However, they have used the SCS dimensionless unit hydrograph. On July 12, 2004, revisions to the NRCS guidelines were adopted that mandated the use of the DelMarva unit hydrograph in some areas of the state. In particular, this updated unit hydrograph should be used for agricultural areas with slopes of less than 5% in this portion of Hamilton Township. However, when this mistaken assumption is corrected the development still meets the required peak flow reductions.**

3. *In computing pre-construction stormwater runoff, the design engineer shall account for all significant land features and structures, such as ponds, wetlands, depressions, hedgerows, or culverts, that may reduce pre-construction stormwater runoff rates and volumes.*

**F. The post-developed hydrological analysis designates 2.62 acres of brush in drainage Sections II and III. However, no brushy areas were designated in the existing condition of the site. It is not clear precisely how the brush was characterized in the existing condition. Based on the stormwater report, this area could have been designated as small grain, woods or meadow. I have run a comparison of the runoff characteristics for each of these land covers using HydroCAD 9.0<sup>1</sup>. The results indicate that, at most, the existing runoff flows were overestimated by 0.95 cfs, 1.99 cfs and 3.37 cfs for the 2, 10 and 100 year storms, respectively<sup>2</sup>. If these flows are subtracted from the existing flows of Table 1, this would account for the brushy areas. The result is that the site still easily meets the peak flow reductions. However, since the brush was not accounted for in the hydrological analysis, this project has not met the requirements of this section of the Rule and Ordinance.**

4. *In computing stormwater runoff from all design storms, the design engineer shall consider the relative stormwater runoff rates and/or volumes of pervious and impervious surfaces separately to accurately compute the rates and volume of stormwater runoff from the site.*

**G. The engineer did not route the pervious and impervious areas separately for the post developed drainage areas labeled Sections I, II and III. This has the effect of underestimating the peak flows after development. The results of the HydroCAD analysis presented in Table 1 indicate that when this mistaken assumption is corrected, the peak flow reductions are still met for all three storm events. However, this project still has not met the requirements of this section of the Rule or the Ordinance.**

7:8-5.7 Standards for structural stormwater management measures [158-6. (a)]

*(a) Standards for structural stormwater management measures are as follows:*

1. *Structural stormwater management measures shall be designed to take into account the existing site conditions, including, for example, environmentally critical areas; wetlands; flood-prone areas; slopes; depth to seasonal high water table; soil type, permeability and texture; drainage area and drainage patterns; and the presence of solution-prone carbonate rocks (limestone).*

**H. The design engineer considered all of the soils on the site to consist of HSG B soils. However, there are also HSG A and C soils on the site. Therefore this portion of the Rule and Ordinance has not been met. It should be noted, however, that the HSG A soils have been largely undisturbed with the exception of the siting of the detention basin and one home site. Thus, it is likely that a revised analysis would yield peak flow reductions that still meet the Rule and Ordinance; HSG A soils generate much less runoff in their undisturbed state than either the HSG B or C soils. Furthermore, the development's peak**

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<sup>1</sup> This analysis can be found in Attachment B.

<sup>2</sup> These values represent the difference in runoff between Brush and Small Grain.

**flow reductions are much greater than required to meet the Rule and Ordinance thereby providing a large margin of safety.**

*(2) Structural stormwater management measures shall be designed to minimize maintenance, facilitate maintenance and repairs, and ensure proper functioning.*

**I. No soil investigations were performed in the area of the detention basin. The basin is located in an area of predominantly Tinton soils. Smaller portions of the basin are located in Galestown soils and Sandy and Silty Land. Tinton and Galestown soils typically exhibit a depth to groundwater in excess of 6.5' while Sandy and Silty Land generally has groundwater at depths as little as 4.0' below the surface. The basin will require 8' cuts into the existing soil. Thus, it cannot be concluded that the 1' separation between the basin bottom and the Seasonal High Water Table level will be achieved and the functioning of the basin cannot be assured. Therefore, this portion of the Rule and the Ordinance has not been met.**

### Conclusions

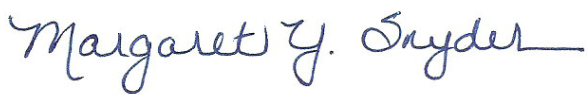
The proposed stormwater management system for Hamilton Estates is not in compliance with the New Jersey Stormwater Rule or the Hamilton Township Stormwater Control Ordinance and may not have been suitably designed based upon the following findings:

- The hydrological analysis did not route the pervious and impervious areas separately for all of the post-developed drainage areas, it did not accurately reflect the soils and brushy areas on the site and it did not use the DelMarva dimensionless unit hydrograph as required by N.J.A.C. 7:8-5.6 and Ordinance section 158-5. (a).
- It has not been documented that the detention basin bottom will achieve the required 1' separation from the Seasonal High Water Table level as required by N.J.A.C. 7:8-5.7 and Ordinance section 158-6. (a).

It should be noted that despite the improper modeling assumptions, the required peak flow reductions are easily met for all three storm events, the required 80% TSS removal rate is achieved, groundwater recharge is maintained and nonstructural stormwater management strategies have been utilized to the maximum extent practicable.

Please feel free to contact me if you would like to discuss these issues.

Sincerely,

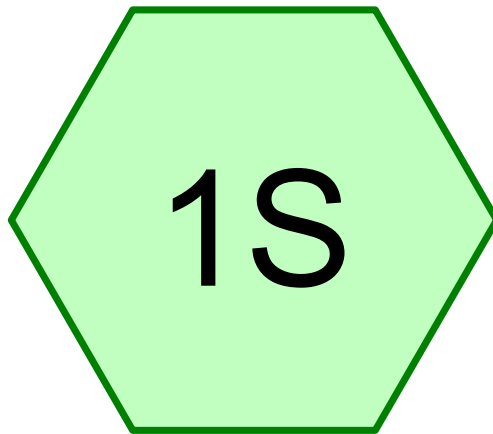


Margaret Y. Snyder, P.E.  
Principal

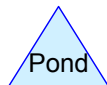
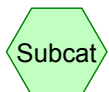
ATTACHMENT A

HYDROLOGICAL ANALYSES USING DELMARVA UNIT HYDROGRAPH  
AND ROUTING PERVIOUS AND IMPERVIOUS AREAS SEPARATELY





# Existing Drainage Area



**Drainage Diagram for Hamilton Estates Existing**  
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## Hamilton Estates Existing

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Page 2

### Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.500	55	HSG B Wooded (1S)
1.800	58	HSG B Meadow (1S)
44.220	72	HSG B Small Row Crop (1S)
0.600	85	HSG B Gravel (1S)
0.130	98	Impervious (1S)
<b>49.250</b>		<b>TOTAL AREA</b>

## Hamilton Estates Existing

Prepared by Emerald Environmental Solutions

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### Notes Listing (all nodes)

Line#	Node Number	Notes
1	1S	Revised to utilize Delmarva Unit Hydrograph.

## Hamilton Estates Existing

Type III 24-hr 2 Year Storm Rainfall=3.30"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=Delmarva

Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

**Subcatchment 1S: Existing Drainage Area** Runoff Area=49.250 ac 0.26% Impervious Runoff Depth>0.83"  
Tc=33.0 min CN=71 Runoff=17.40 cfs 3.409 af

**Total Runoff Area = 49.250 ac Runoff Volume = 3.409 af Average Runoff Depth = 0.83"**  
**99.74% Pervious = 49.120 ac 0.26% Impervious = 0.130 ac**

## Hamilton Estates Existing

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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 1S: Existing Drainage Area

Revised to utilize Delmarva Unit Hydrograph.

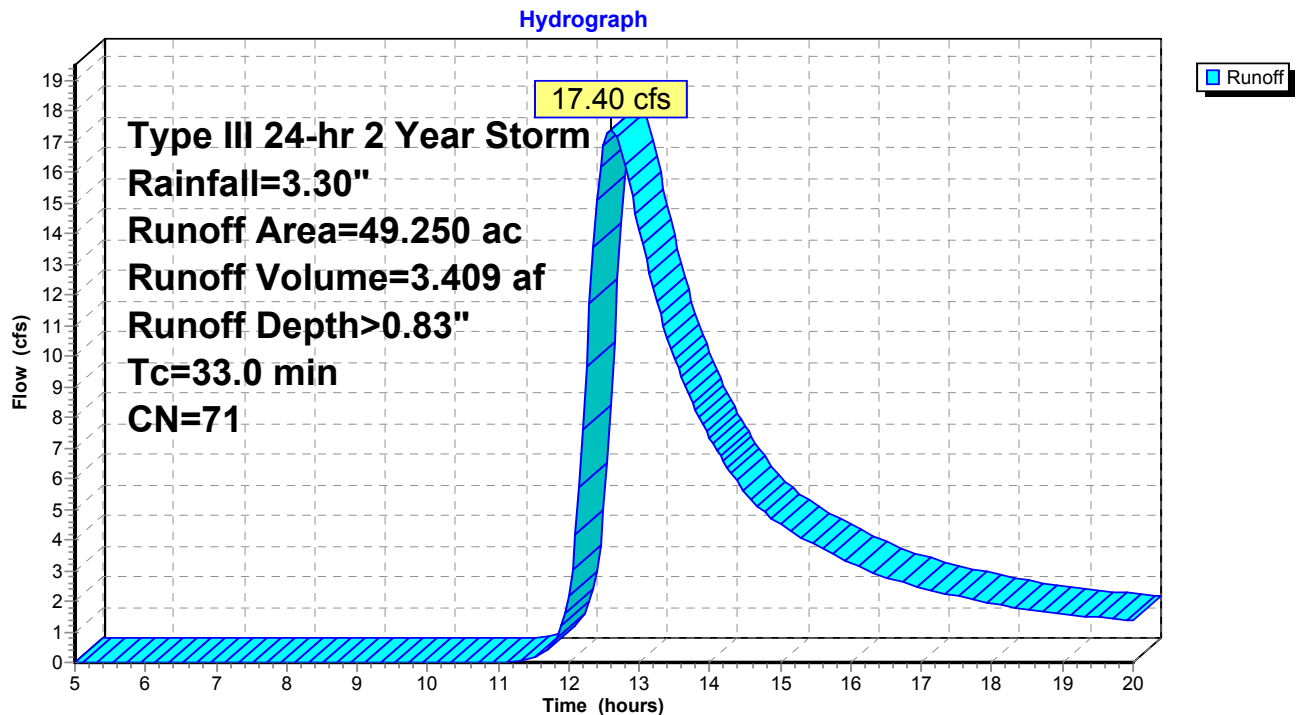
Runoff = 17.40 cfs @ 12.61 hrs, Volume= 3.409 af, Depth> 0.83"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 0.130	98	Impervious
* 0.600	85	HSG B Gravel
* 44.220	72	HSG B Small Row Crop
* 2.500	55	HSG B Wooded
* 1.800	58	HSG B Meadow
49.250	71	Weighted Average
49.120		99.74% Pervious Area
0.130		0.26% Impervious Area

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

### Subcatchment 1S: Existing Drainage Area



## Hamilton Estates Existing

Type III 24-hr 10 Year Storm Rainfall=5.00"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=Delmarva

Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

**Subcatchment 1S: Existing Drainage Area** Runoff Area=49.250 ac 0.26% Impervious Runoff Depth>1.91"  
Tc=33.0 min CN=71 Runoff=42.86 cfs 7.852 af

**Total Runoff Area = 49.250 ac Runoff Volume = 7.852 af Average Runoff Depth = 1.91"**  
**99.74% Pervious = 49.120 ac 0.26% Impervious = 0.130 ac**

## Hamilton Estates Existing

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Type III 24-hr 10 Year Storm Rainfall=5.00"

Printed 12/21/2009

Page 7

### Summary for Subcatchment 1S: Existing Drainage Area

Revised to utilize Delmarva Unit Hydrograph.

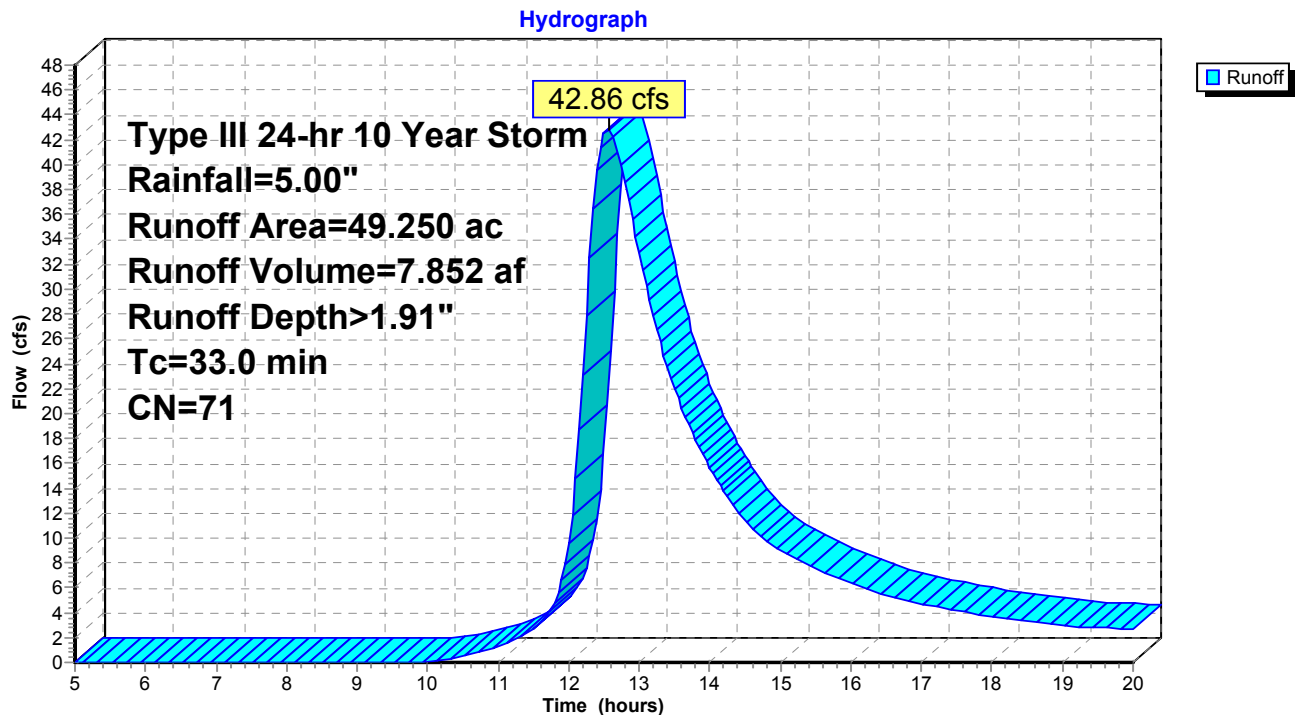
Runoff = 42.86 cfs @ 12.56 hrs, Volume= 7.852 af, Depth> 1.91"

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

Area (ac)	CN	Description
* 0.130	98	Impervious
* 0.600	85	HSG B Gravel
* 44.220	72	HSG B Small Row Crop
* 2.500	55	HSG B Wooded
* 1.800	58	HSG B Meadow
49.250	71	Weighted Average
49.120		99.74% Pervious Area
0.130		0.26% Impervious Area

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

### Subcatchment 1S: Existing Drainage Area



## Hamilton Estates Existing

Type III 24-hr 100 Year Storm Rainfall=8.30"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=Delmarva

Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

**Subcatchment 1S: Existing Drainage Area** Runoff Area=49.250 ac 0.26% Impervious Runoff Depth>4.45"  
Tc=33.0 min CN=71 Runoff=101.12 cfs 18.254 af

**Total Runoff Area = 49.250 ac Runoff Volume = 18.254 af Average Runoff Depth = 4.45"**  
**99.74% Pervious = 49.120 ac 0.26% Impervious = 0.130 ac**



## Hamilton Estates Existing

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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 1S: Existing Drainage Area

Revised to utilize Delmarva Unit Hydrograph.

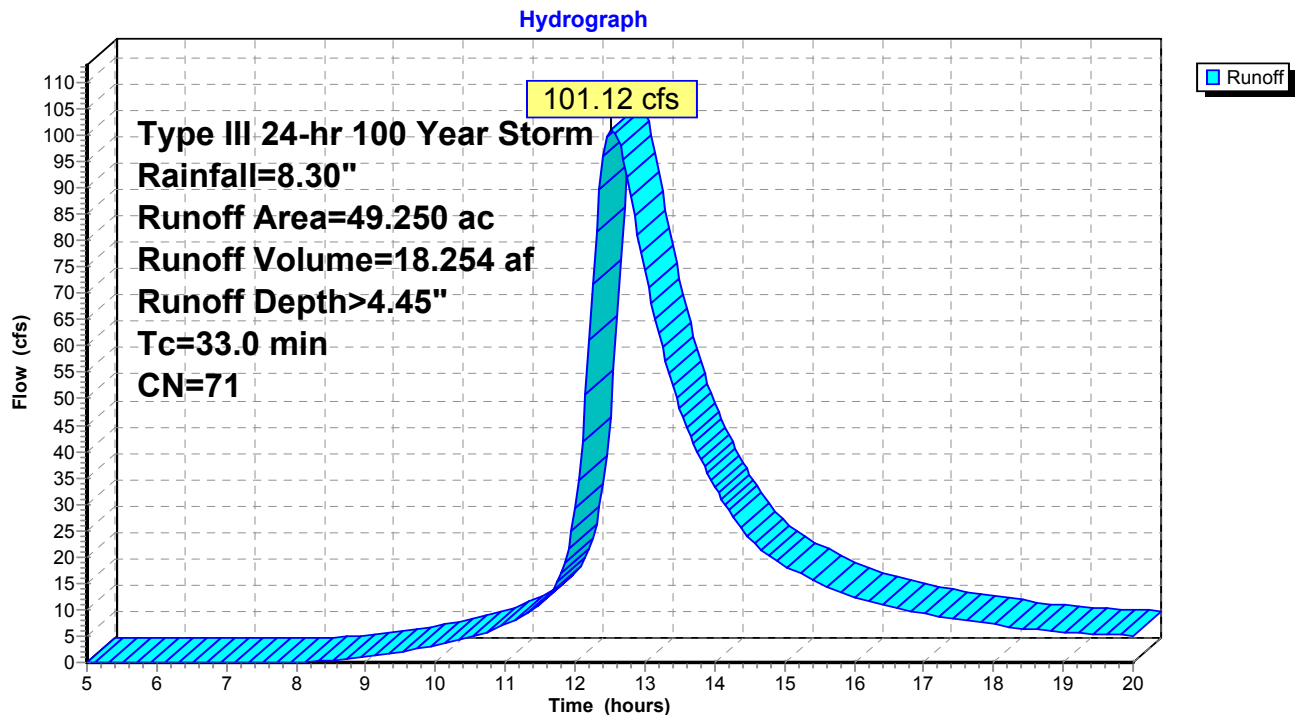
Runoff = 101.12 cfs @ 12.53 hrs, Volume= 18.254 af, Depth> 4.45"

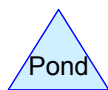
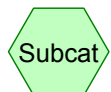
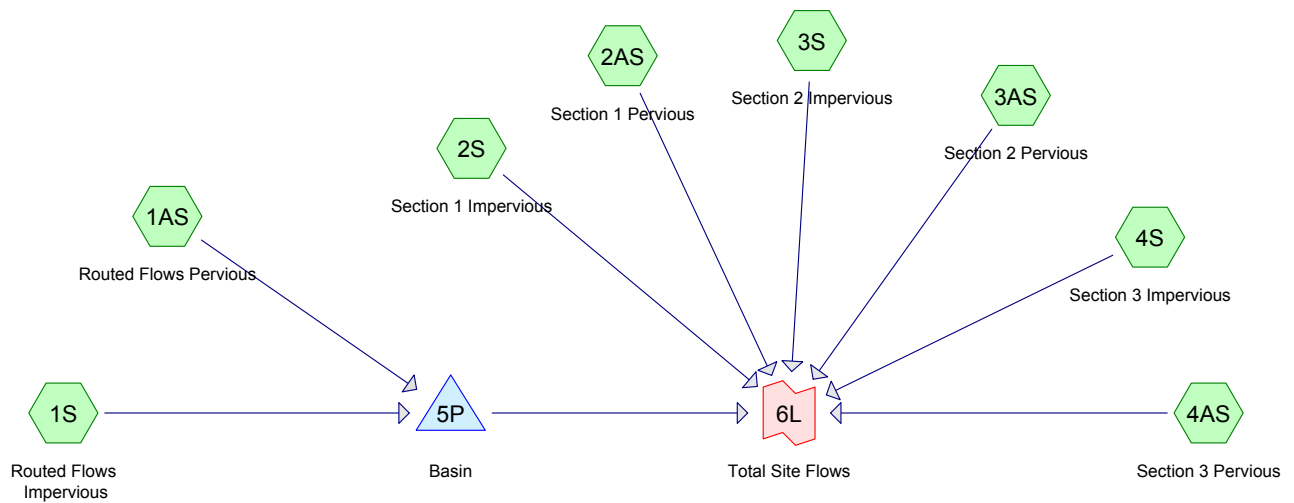
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 0.130	98	Impervious
* 0.600	85	HSG B Gravel
* 44.220	72	HSG B Small Row Crop
* 2.500	55	HSG B Wooded
* 1.800	58	HSG B Meadow
49.250	71	Weighted Average
49.120		99.74% Pervious Area
0.130		0.26% Impervious Area

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

### Subcatchment 1S: Existing Drainage Area





**Drainage Diagram for Hamilton Estates Proposed**  
 Prepared by Emerald Environmental Solutions, Printed 12/21/2009  
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## Hamilton Estates Proposed

Prepared by Emerald Environmental Solutions

Printed 12/21/2009

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Page 2

### Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.620	48	HSG B Brush (3AS, 4AS)
1.500	55	HSG B Woods (2AS)
2.990	61	HSG B Grass (4AS)
37.930	61	HSG B Open Space (1AS, 2AS, 3AS)
5.250	98	Impervious (1S, 2S, 3S, 4S)
<b>50.290</b>		<b>TOTAL AREA</b>

## Hamilton Estates Proposed

Prepared by Emerald Environmental Solutions

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Page 3

### Notes Listing (all nodes)

Line#	Node Number	Notes
1	6L	Revised to utilize Delmarva Unit Hydrograph.
2		Revised to route pervious and impervious areas separately.

**Hamilton Estates Proposed***Type III 24-hr 2 Year Storm Rainfall=3.30"*

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Time span=0.00-20.00 hrs, dt=0.05 hrs, 401 points  
Runoff by SCS TR-20 method, UH=Delmarva  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

**Subcatchment 1AS: Routed Flows Pervious** Runoff Area=14.710 ac 0.00% Impervious Runoff Depth>0.41"  
Tc=31.2 min CN=61 Runoff=2.12 cfs 0.506 af

**Subcatchment 1S: Routed Flows** Runoff Area=3.850 ac 100.00% Impervious Runoff Depth>2.92"  
Tc=10.0 min CN=98 Runoff=8.23 cfs 0.935 af

**Subcatchment 2AS: Section 1 Pervious** Runoff Area=24.290 ac 0.00% Impervious Runoff Depth>0.41"  
Tc=30.6 min CN=61 Runoff=3.53 cfs 0.836 af

**Subcatchment 2S: Section 1 Impervious** Runoff Area=0.850 ac 100.00% Impervious Runoff Depth>2.92"  
Tc=10.0 min CN=98 Runoff=1.82 cfs 0.207 af

**Subcatchment 3AS: Section 2 Pervious** Runoff Area=1.100 ac 0.00% Impervious Runoff Depth>0.18"  
Tc=10.0 min CN=53 Runoff=0.07 cfs 0.017 af

**Subcatchment 3S: Section 2 Impervious** Runoff Area=0.050 ac 100.00% Impervious Runoff Depth>2.92"  
Tc=10.0 min CN=98 Runoff=0.11 cfs 0.012 af

**Subcatchment 4AS: Section 3 Pervious** Runoff Area=4.940 ac 0.00% Impervious Runoff Depth>0.26"  
Tc=10.0 min CN=56 Runoff=0.59 cfs 0.108 af

**Subcatchment 4S: Section 3 Impervious** Runoff Area=0.500 ac 100.00% Impervious Runoff Depth>2.92"  
Tc=10.0 min CN=98 Runoff=1.07 cfs 0.121 af

**Pond 5P: Basin** Peak Elev=50.81' Storage=40,979 cf Inflow=8.56 cfs 1.441 af  
Outflow=1.10 cfs 0.580 af

**Link 6L: Total Site Flows** Inflow=5.69 cfs 1.881 af  
Primary=5.69 cfs 1.881 af

**Total Runoff Area = 50.290 ac Runoff Volume = 2.743 af Average Runoff Depth = 0.65"**  
**89.56% Pervious = 45.040 ac 10.44% Impervious = 5.250 ac**

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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 1AS: Routed Flows Pervious

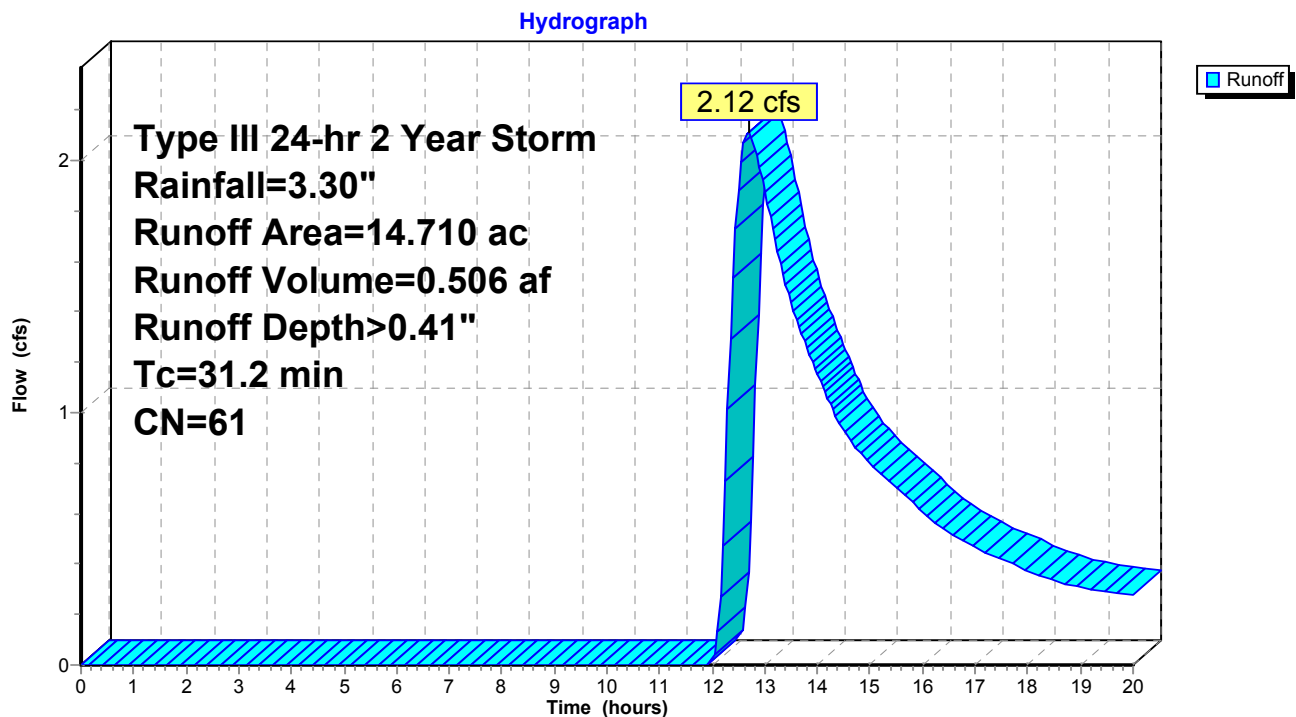
Runoff = 2.12 cfs @ 12.69 hrs, Volume= 0.506 af, Depth> 0.41"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 14.710	61	HSG B Open Space
14.710		100.00% Pervious Area

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

### Subcatchment 1AS: Routed Flows Pervious



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### Summary for Subcatchment 1S: Routed Flows Impervious

Runoff = 8.23 cfs @ 12.16 hrs, Volume= 0.935 af, Depth> 2.92"

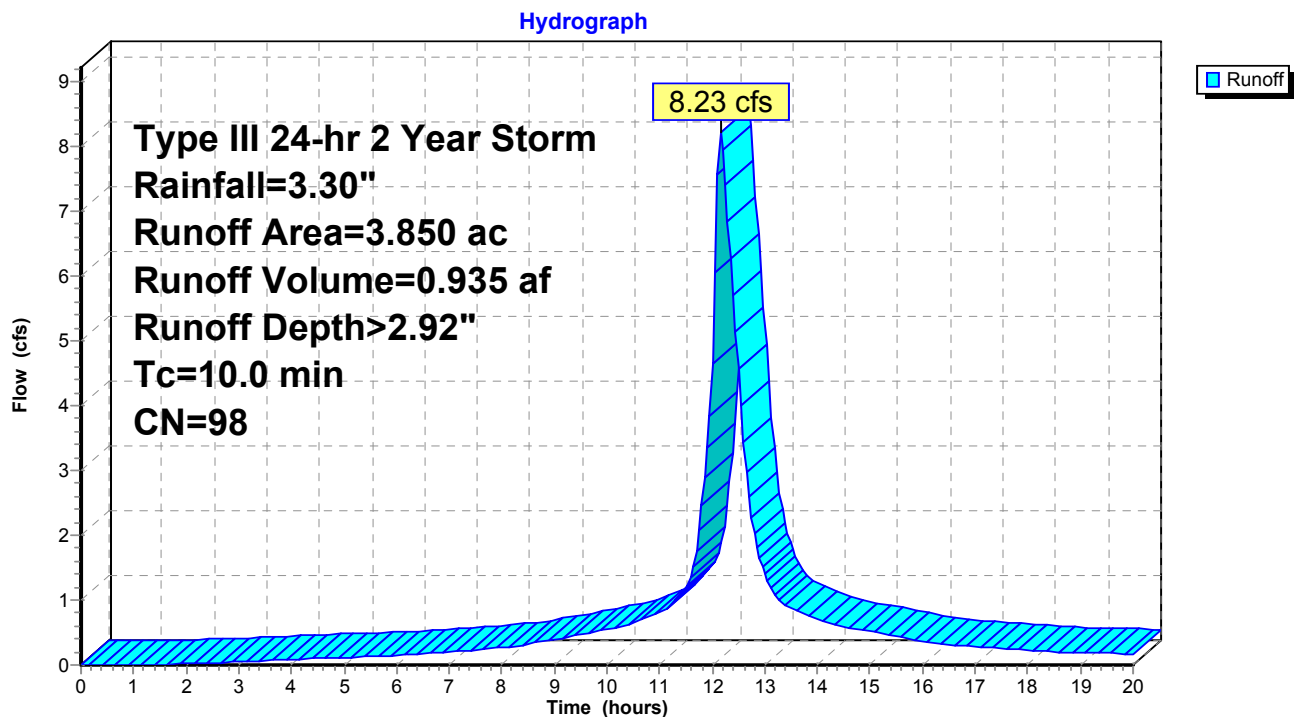
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 3.850	98	Impervious
3.850		100.00% Impervious Area

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

### Subcatchment 1S: Routed Flows Impervious



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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 2AS: Section 1 Pervious

Runoff = 3.53 cfs @ 12.68 hrs, Volume= 0.836 af, Depth> 0.41"

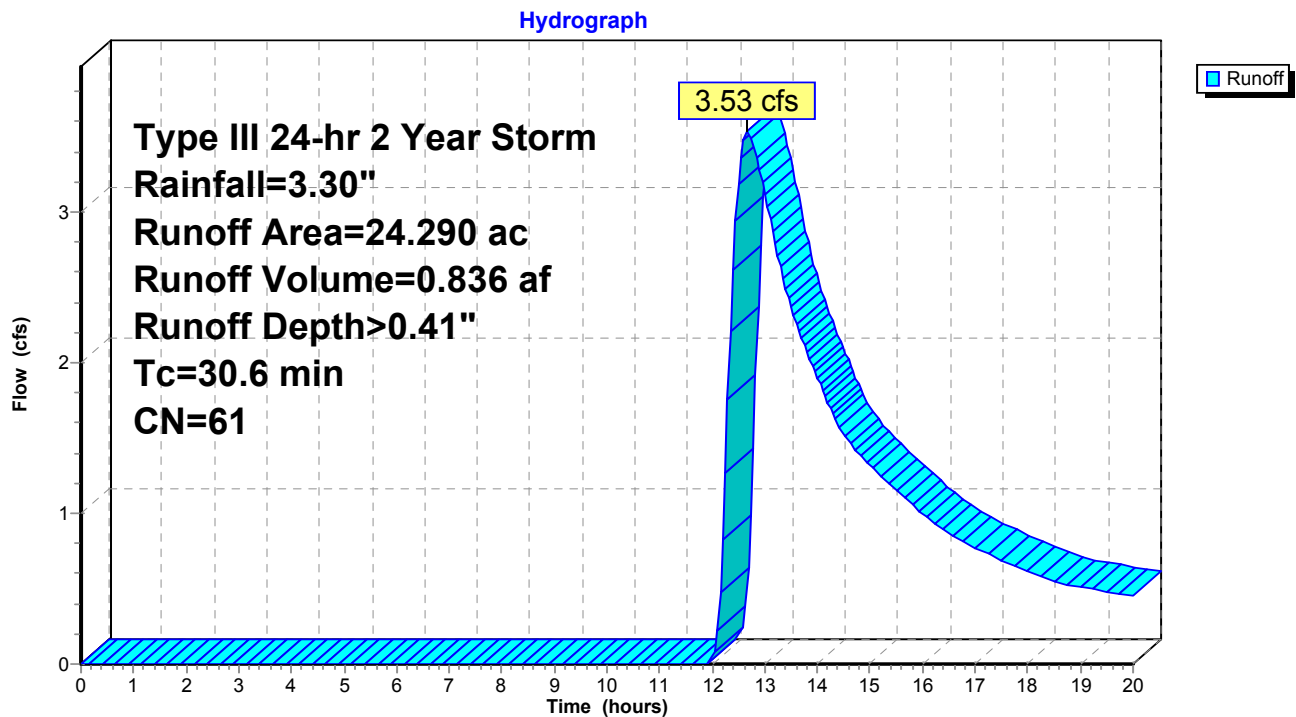
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 22.790	61	HSG B Open Space
* 1.500	55	HSG B Woods
24.290	61	Weighted Average
24.290		100.00% Pervious Area

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

### Subcatchment 2AS: Section 1 Pervious





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### Summary for Subcatchment 2S: Section 1 Impervious

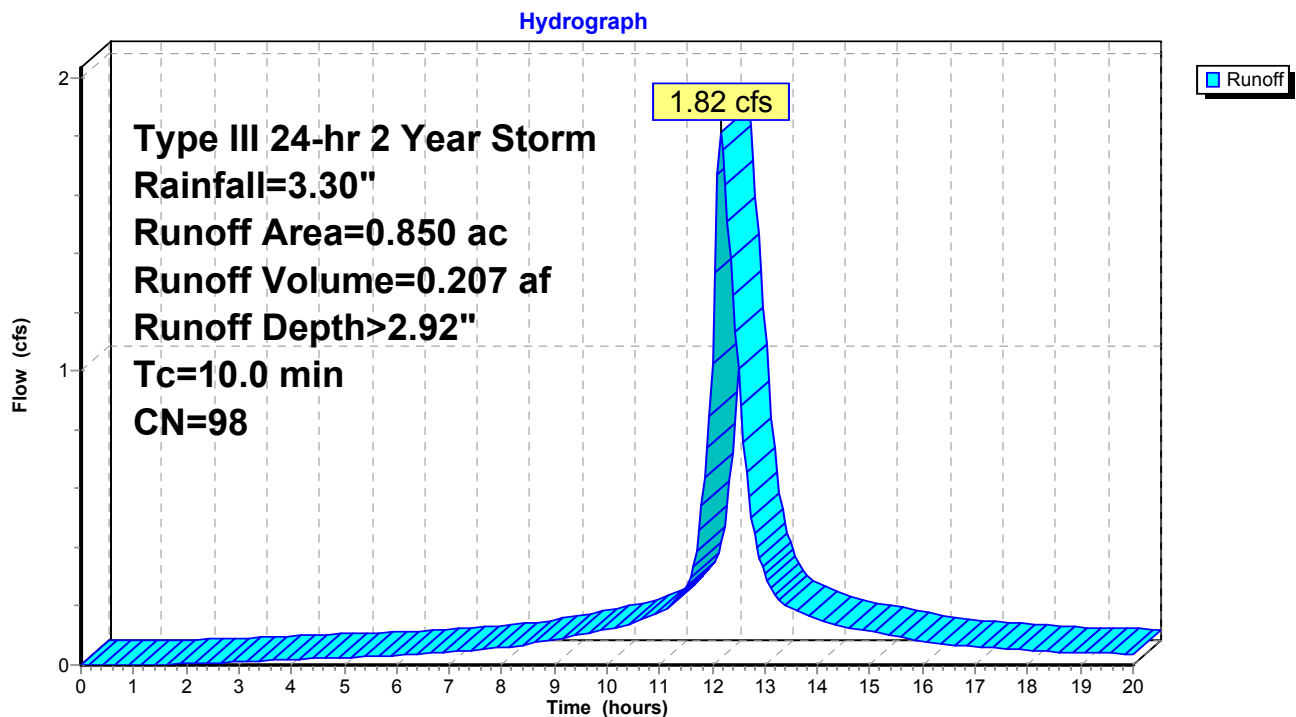
Runoff = 1.82 cfs @ 12.16 hrs, Volume= 0.207 af, Depth> 2.92"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 0.850	98	Impervious
0.850		100.00% Impervious Area

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

### Subcatchment 2S: Section 1 Impervious



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### Summary for Subcatchment 3AS: Section 2 Pervious

Runoff = 0.07 cfs @ 12.50 hrs, Volume= 0.017 af, Depth> 0.18"

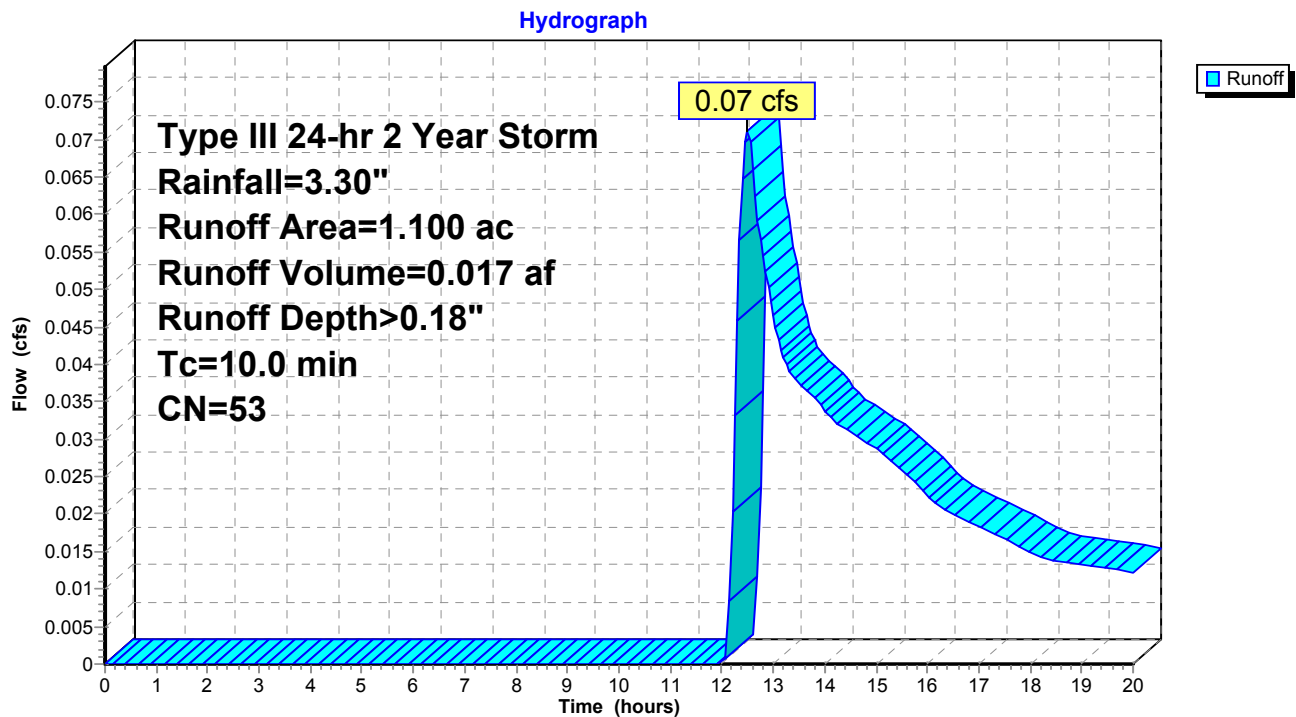
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 0.670	48	HSG B Brush
* 0.430	61	HSG B Open Space
1.100	53	Weighted Average
1.100		100.00% Pervious Area

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

### Subcatchment 3AS: Section 2 Pervious



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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 3S: Section 2 Impervious

Runoff = 0.11 cfs @ 12.16 hrs, Volume= 0.012 af, Depth> 2.92"

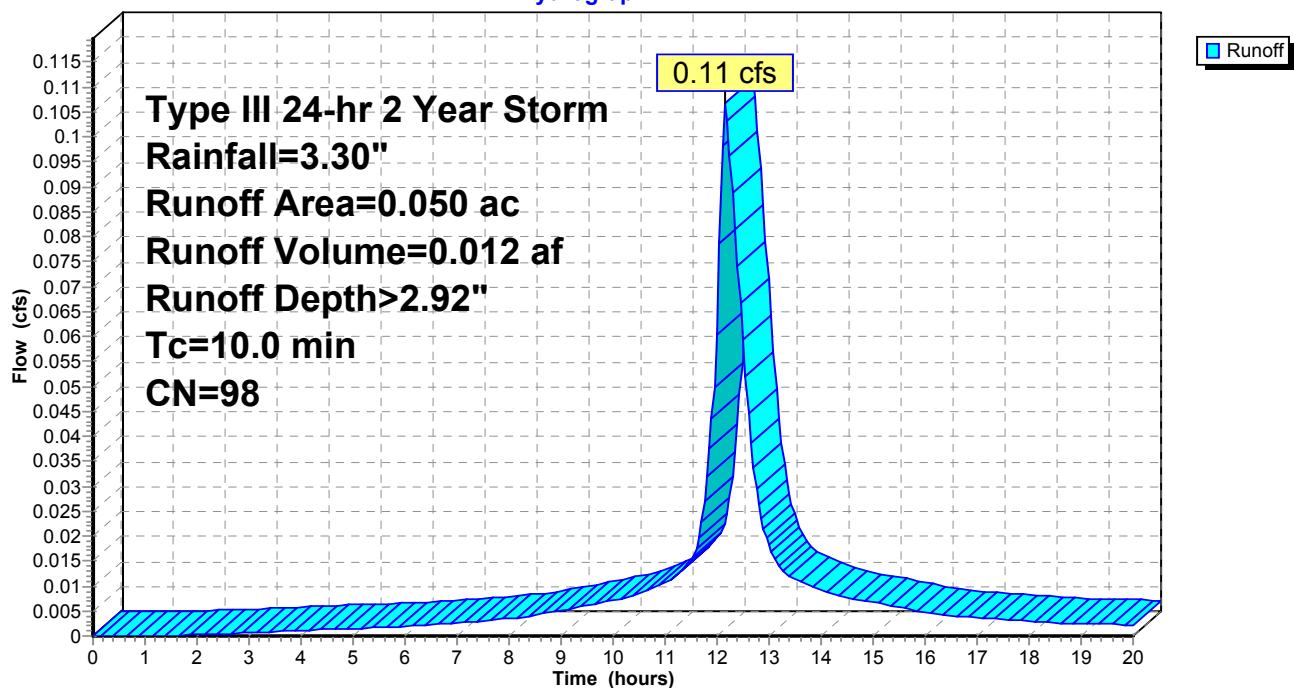
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 0.050	98	Impervious
0.050		100.00% Impervious Area

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

### Subcatchment 3S: Section 2 Impervious

Hydrograph



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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 4AS: Section 3 Pervious

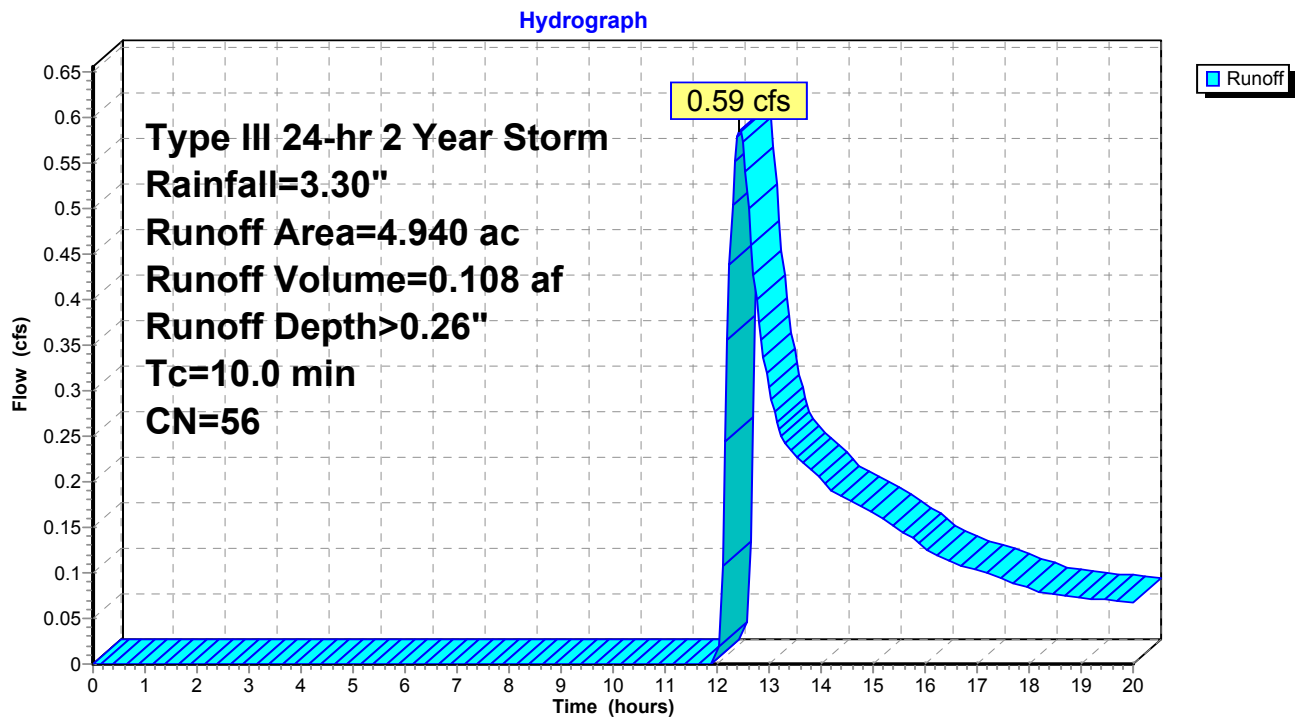
Runoff = 0.59 cfs @ 12.44 hrs, Volume= 0.108 af, Depth> 0.26"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 Year Storm Rainfall=3.30"

	Area (ac)	CN	Description
*	1.950	48	HSG B Brush
*	2.990	61	HSG B Grass
	4.940	56	Weighted Average
	4.940		100.00% Pervious Area

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

### Subcatchment 4AS: Section 3 Pervious



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### Summary for Subcatchment 4S: Section 3 Impervious

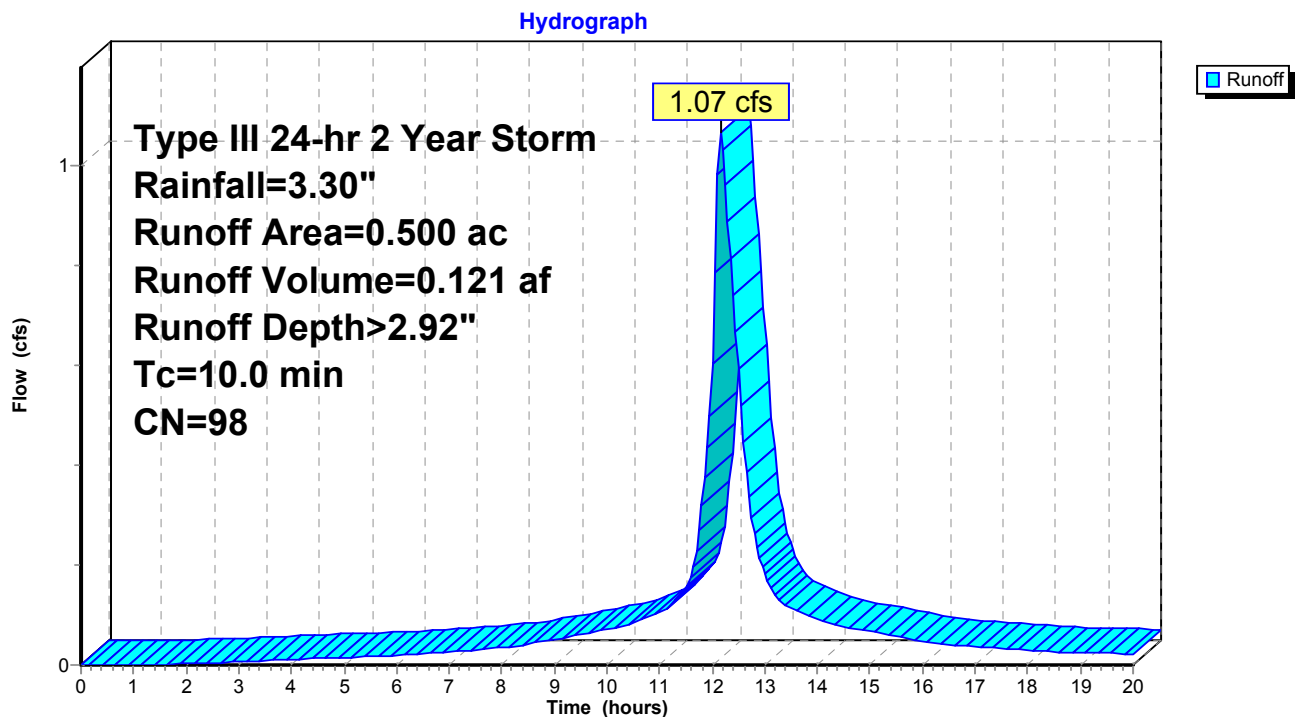
Runoff = 1.07 cfs @ 12.16 hrs, Volume= 0.121 af, Depth> 2.92"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 0.500	98	Impervious
0.500		100.00% Impervious Area

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

### Subcatchment 4S: Section 3 Impervious



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Type III 24-hr 2 Year Storm Rainfall=3.30"

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**Summary for Pond 5P: Basin**

Inflow Area = 18.560 ac, 20.74% Impervious, Inflow Depth > 0.93" for 2 Year Storm event  
 Inflow = 8.56 cfs @ 12.17 hrs, Volume= 1.441 af  
 Outflow = 1.10 cfs @ 15.62 hrs, Volume= 0.580 af, Atten= 87%, Lag= 207.0 min  
 Primary = 1.10 cfs @ 15.62 hrs, Volume= 0.580 af

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
 Peak Elev= 50.81' @ 15.62 hrs Surf.Area= 0 sf Storage= 40,979 cf

Plug-Flow detention time= 274.1 min calculated for 0.580 af (40% of inflow)  
 Center-of-Mass det. time= 139.5 min ( 928.6 - 789.1 )

Volume	Invert	Avail.Storage	Storage Description
#1	48.60'	192,588 cf	<b>Custom Stage Data</b> Listed below

Elevation (feet)	Cum.Store (cubic-feet)
48.60	0
49.00	678
50.00	14,156
51.00	47,136
52.00	96,280
53.00	154,720
53.60	192,588

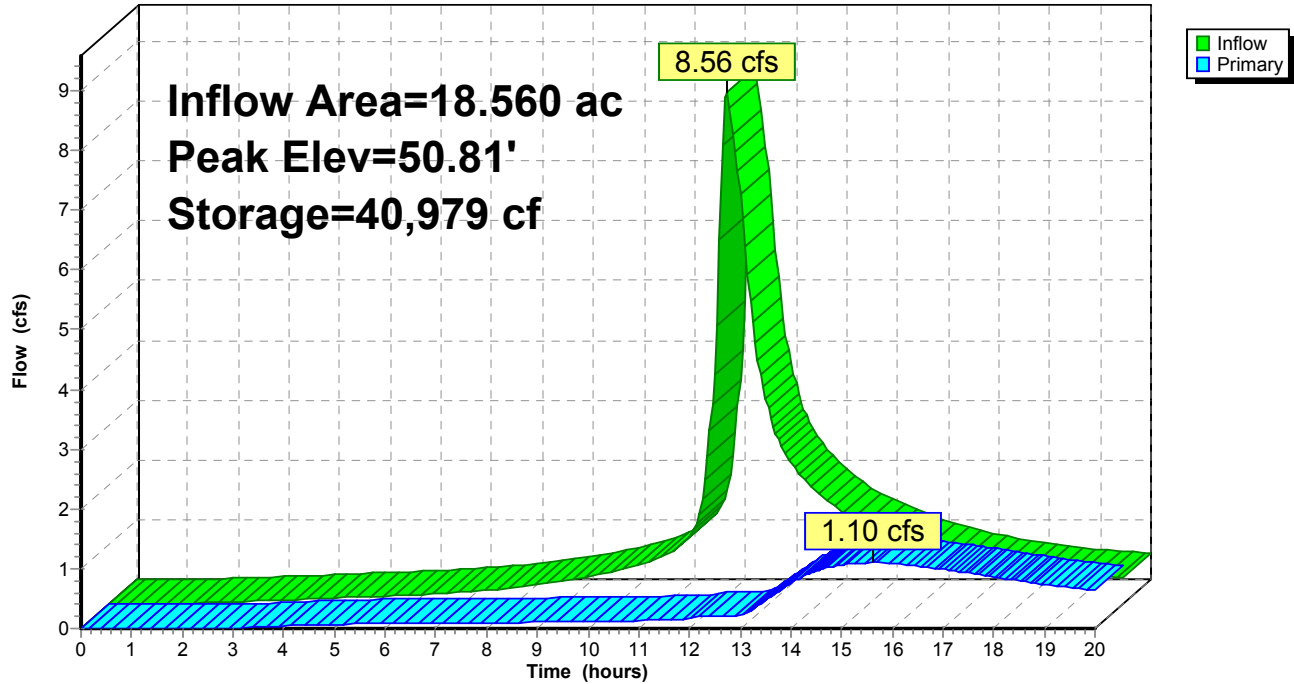
Device	Routing	Invert	Outlet Devices
#1	Primary	47.50'	<b>30.0" Round Culvert</b> L= 136.0' Ke= 0.600 Outlet Invert= 42.00' S= 0.0404 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	48.60'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Device 1	50.55'	<b>2.0' long Sharp-Crested Rectangular Weir</b> 2 End Contraction(s)
#4	Device 1	52.30'	<b>5.0' long Sharp-Crested Rectangular Weir</b> 2 End Contraction(s)

**Primary OutFlow** Max=1.10 cfs @ 15.62 hrs HW=50.81' (Free Discharge)

1=Culvert (Passes 1.10 cfs of 31.83 cfs potential flow)  
 2=Orifice/Grate (Orifice Controls 0.24 cfs @ 6.99 fps)  
 3=Sharp-Crested Rectangular Weir (Weir Controls 0.86 cfs @ 1.68 fps)  
 4=Sharp-Crested Rectangular Weir ( Controls 0.00 cfs)

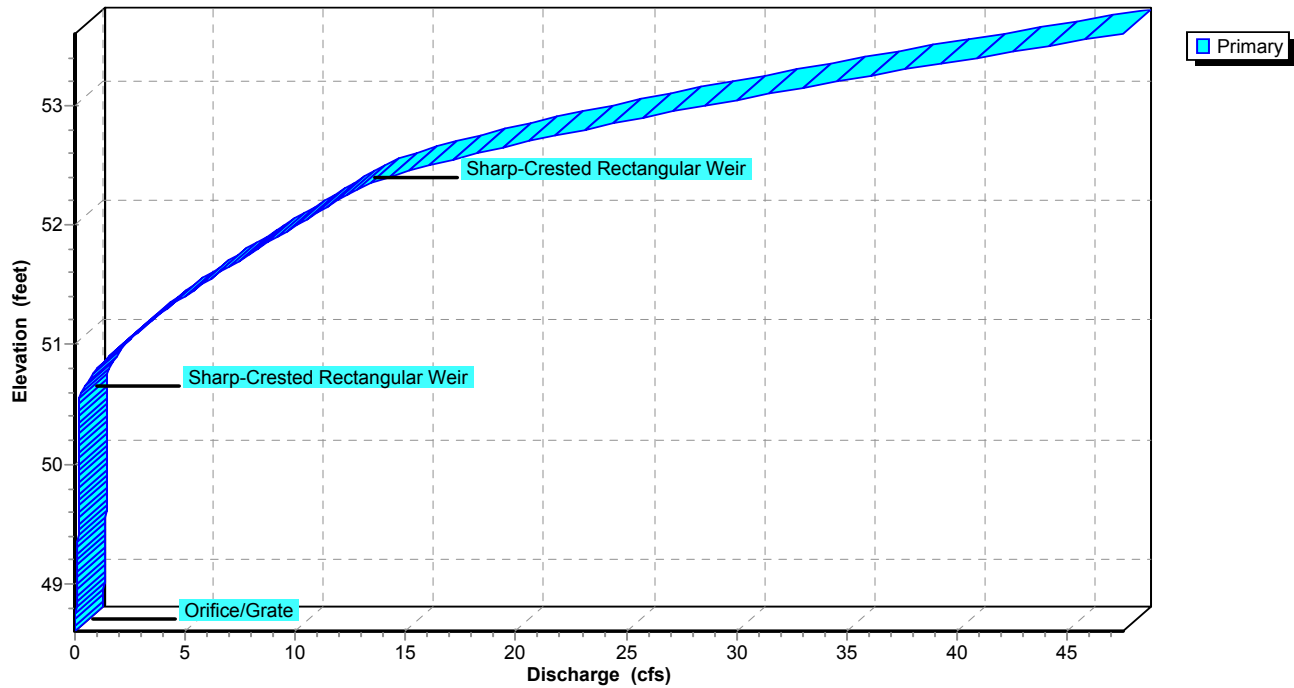
**Pond 5P: Basin**

Hydrograph



**Pond 5P: Basin**

Stage-Discharge



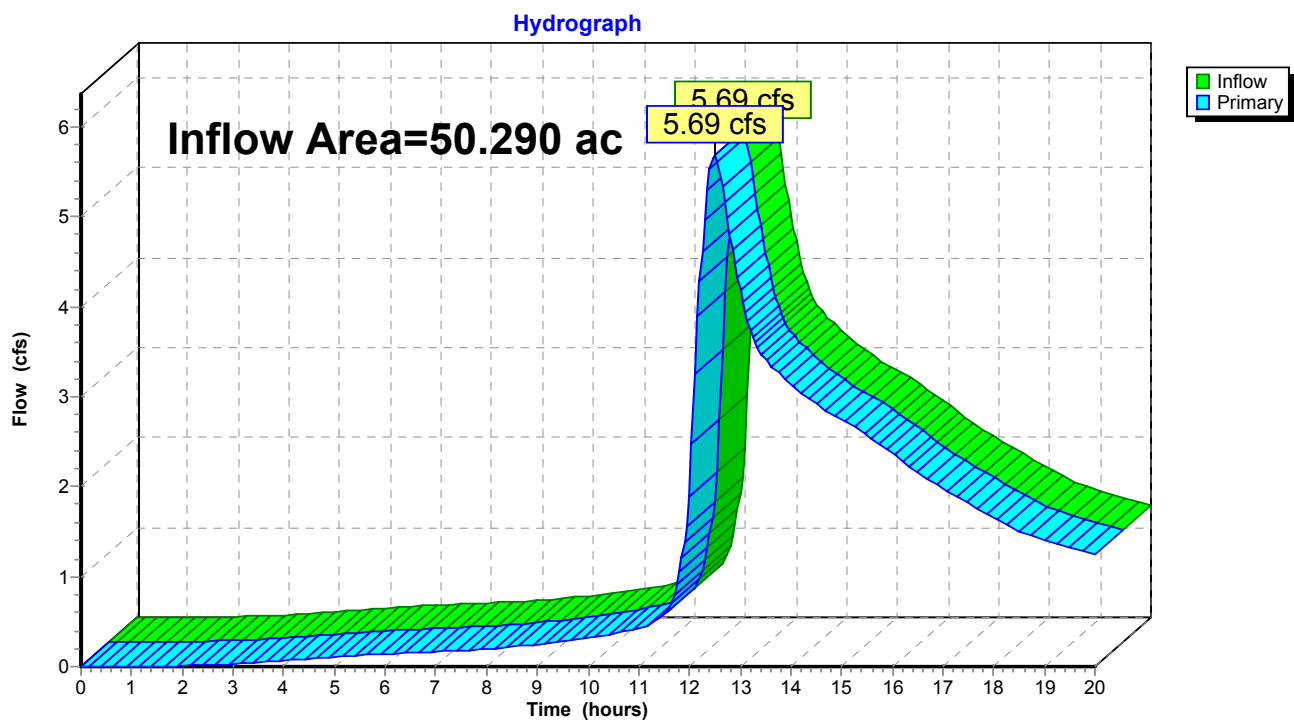
**Summary for Link 6L: Total Site Flows**

Revised to utilize Delmarva Unit Hydrograph.

Revised to route pervious and impervious areas separately.

Inflow Area = 50.290 ac, 10.44% Impervious, Inflow Depth > 0.45" for 2 Year Storm event  
Inflow = 5.69 cfs @ 12.49 hrs, Volume= 1.881 af  
Primary = 5.69 cfs @ 12.49 hrs, Volume= 1.881 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

**Link 6L: Total Site Flows**



**Hamilton Estates Proposed***Type III 24-hr 10 Year Storm Rainfall=5.00"*

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Time span=0.00-20.00 hrs, dt=0.05 hrs, 401 points  
Runoff by SCS TR-20 method, UH=Delmarva  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

<b>Subcatchment 1AS: Routed Flows Pervious</b>	Runoff Area=14.710 ac 0.00% Impervious Runoff Depth>1.21" Tc=31.2 min CN=61 Runoff=7.75 cfs 1.484 af
<b>Subcatchment 1S: Routed Flows</b>	Runoff Area=3.850 ac 100.00% Impervious Runoff Depth>4.53" Tc=10.0 min CN=98 Runoff=12.57 cfs 1.454 af
<b>Subcatchment 2AS: Section 1 Pervious</b>	Runoff Area=24.290 ac 0.00% Impervious Runoff Depth>1.21" Tc=30.6 min CN=61 Runoff=12.93 cfs 2.452 af
<b>Subcatchment 2S: Section 1 Impervious</b>	Runoff Area=0.850 ac 100.00% Impervious Runoff Depth>4.53" Tc=10.0 min CN=98 Runoff=2.78 cfs 0.321 af
<b>Subcatchment 3AS: Section 2 Pervious</b>	Runoff Area=1.100 ac 0.00% Impervious Runoff Depth>0.76" Tc=10.0 min CN=53 Runoff=0.51 cfs 0.069 af
<b>Subcatchment 3S: Section 2 Impervious</b>	Runoff Area=0.050 ac 100.00% Impervious Runoff Depth>4.53" Tc=10.0 min CN=98 Runoff=0.16 cfs 0.019 af
<b>Subcatchment 4AS: Section 3 Pervious</b>	Runoff Area=4.940 ac 0.00% Impervious Runoff Depth>0.93" Tc=10.0 min CN=56 Runoff=3.05 cfs 0.381 af
<b>Subcatchment 4S: Section 3 Impervious</b>	Runoff Area=0.500 ac 100.00% Impervious Runoff Depth>4.53" Tc=10.0 min CN=98 Runoff=1.63 cfs 0.189 af
<b>Pond 5P: Basin</b>	Peak Elev=51.35' Storage=64,104 cf Inflow=15.87 cfs 2.939 af Outflow=4.54 cfs 1.966 af
<b>Link 6L: Total Site Flows</b>	Inflow=19.80 cfs 5.397 af Primary=19.80 cfs 5.397 af

**Total Runoff Area = 50.290 ac Runoff Volume = 6.370 af Average Runoff Depth = 1.52"**  
**89.56% Pervious = 45.040 ac 10.44% Impervious = 5.250 ac**

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Type III 24-hr 10 Year Storm Rainfall=5.00"

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### Summary for Subcatchment 1AS: Routed Flows Pervious

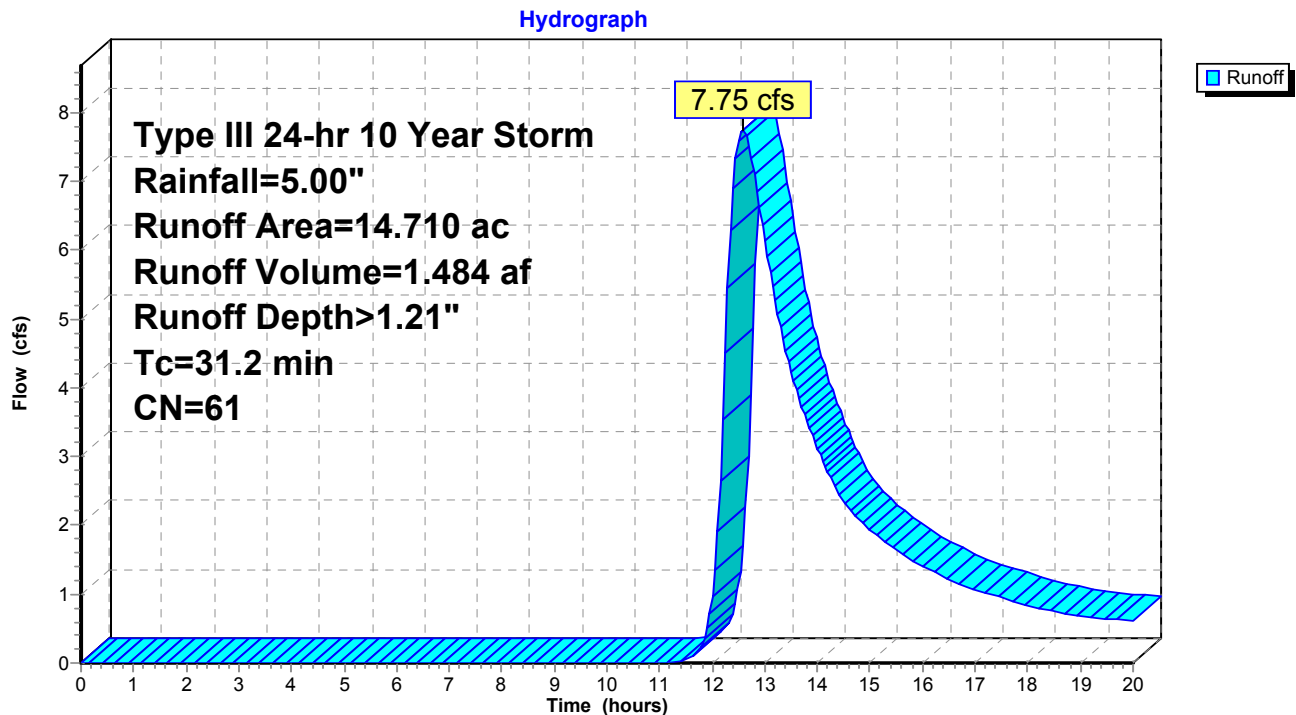
Runoff = 7.75 cfs @ 12.59 hrs, Volume= 1.484 af, Depth> 1.21"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 14.710	61	HSG B Open Space
14.710		100.00% Pervious Area

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

### Subcatchment 1AS: Routed Flows Pervious



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### Summary for Subcatchment 1S: Routed Flows Impervious

Runoff = 12.57 cfs @ 12.16 hrs, Volume= 1.454 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

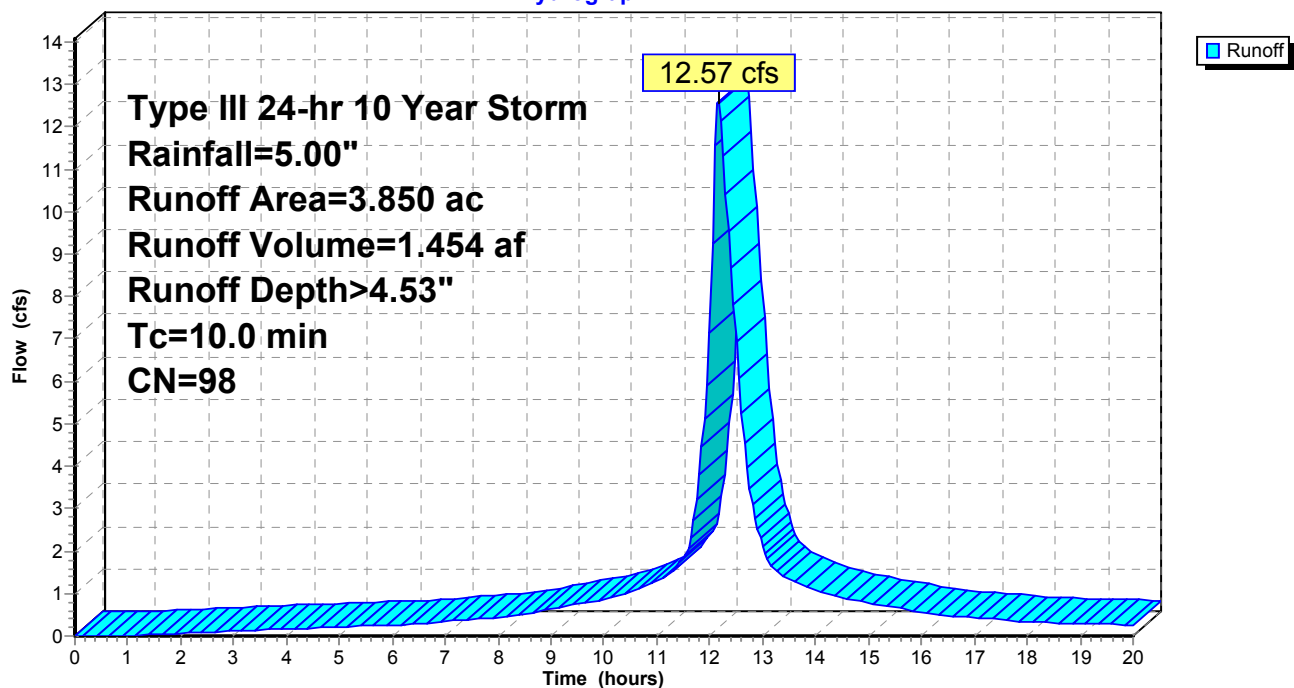
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 3.850	98	Impervious
3.850		100.00% Impervious Area

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

### Subcatchment 1S: Routed Flows Impervious

Hydrograph



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### Summary for Subcatchment 2AS: Section 1 Pervious

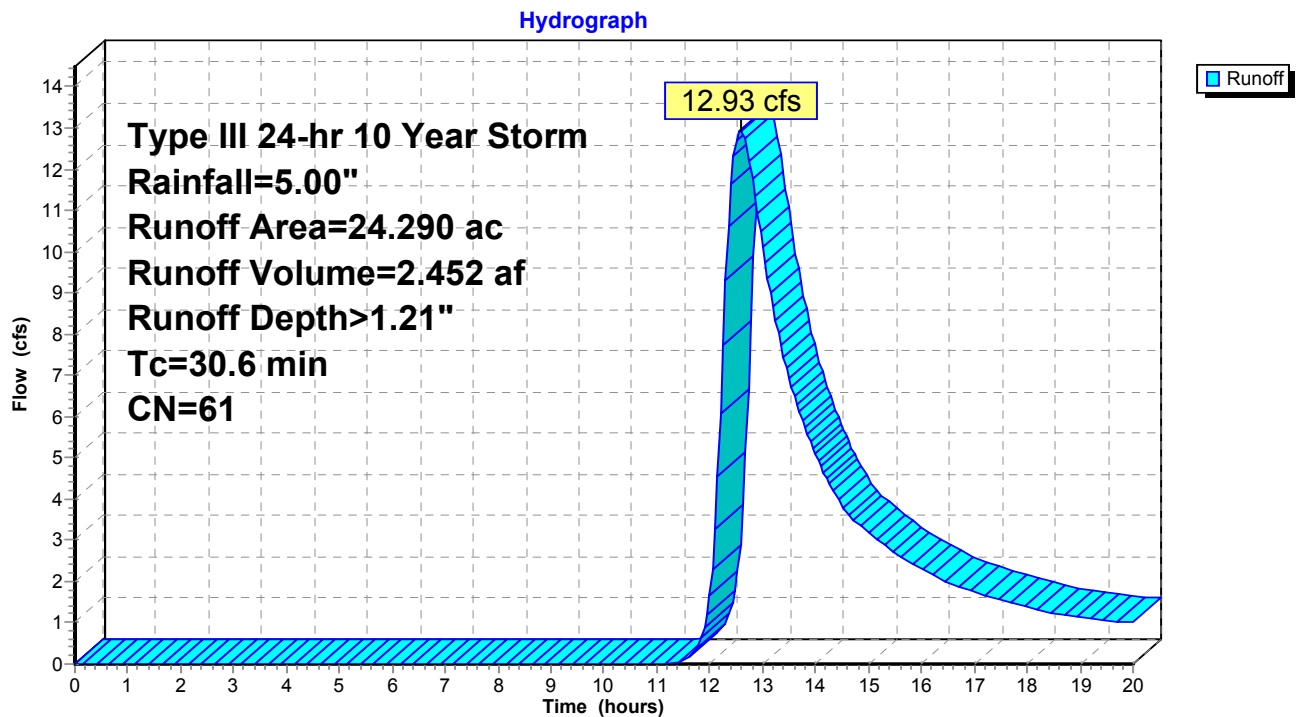
Runoff = 12.93 cfs @ 12.58 hrs, Volume= 2.452 af, Depth> 1.21"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 22.790	61	HSG B Open Space
* 1.500	55	HSG B Woods
24.290	61	Weighted Average
24.290		100.00% Pervious Area

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

### Subcatchment 2AS: Section 1 Pervious



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Type III 24-hr 10 Year Storm Rainfall=5.00"

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### Summary for Subcatchment 2S: Section 1 Impervious

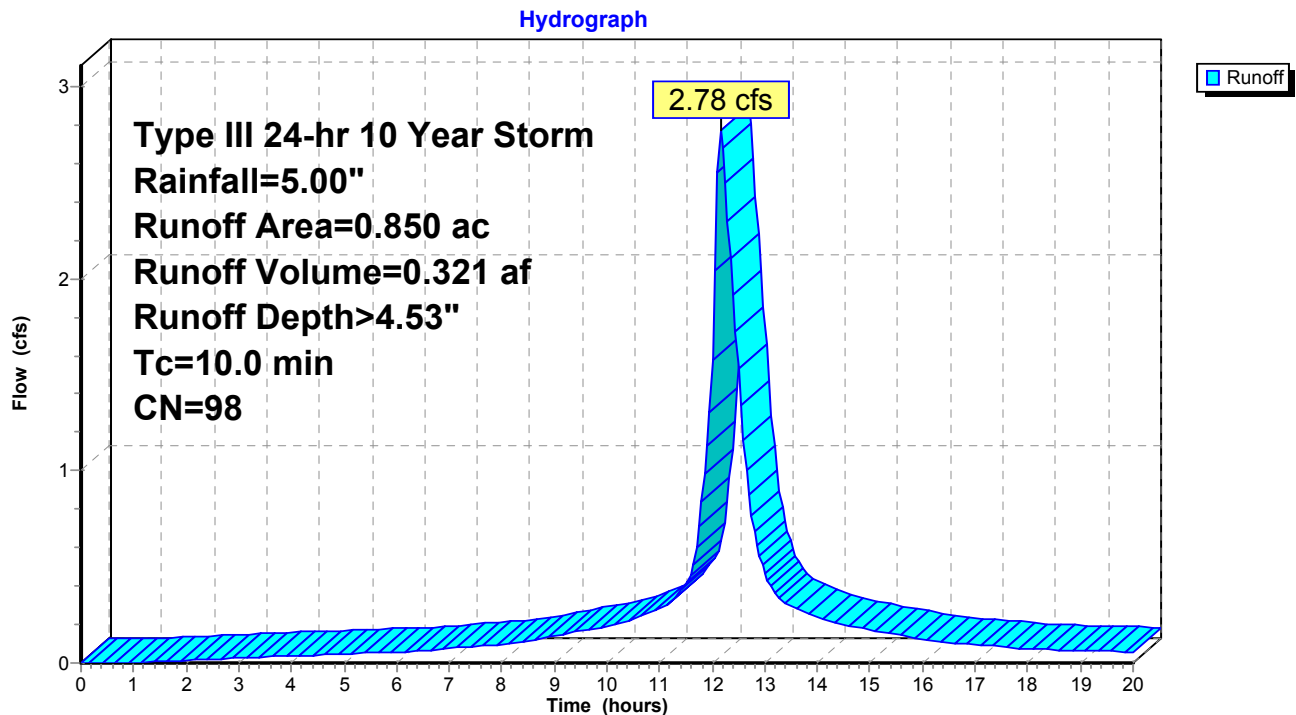
Runoff = 2.78 cfs @ 12.16 hrs, Volume= 0.321 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 0.850	98	Impervious
0.850		100.00% Impervious Area

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

### Subcatchment 2S: Section 1 Impervious



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### Summary for Subcatchment 3AS: Section 2 Pervious

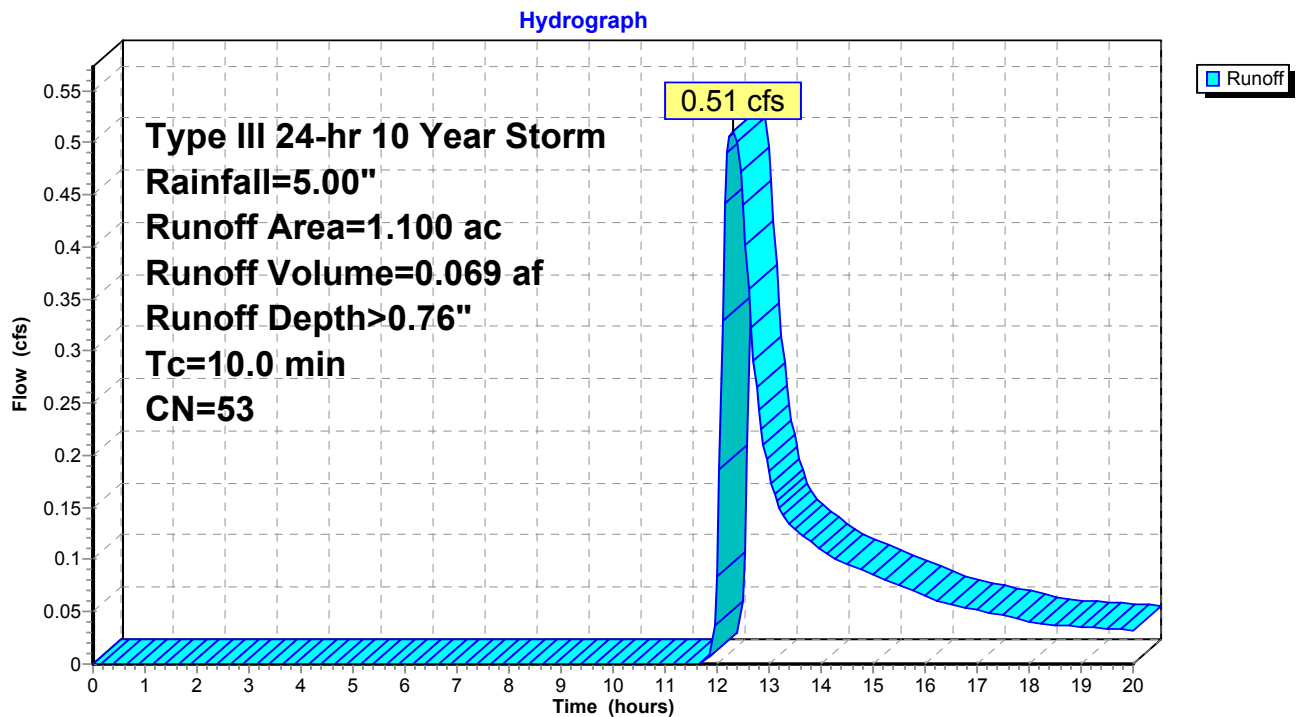
Runoff = 0.51 cfs @ 12.30 hrs, Volume= 0.069 af, Depth> 0.76"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 0.670	48	HSG B Brush
* 0.430	61	HSG B Open Space
1.100	53	Weighted Average
1.100		100.00% Pervious Area

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

### Subcatchment 3AS: Section 2 Pervious



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### Summary for Subcatchment 3S: Section 2 Impervious

Runoff = 0.16 cfs @ 12.16 hrs, Volume= 0.019 af, Depth> 4.53"

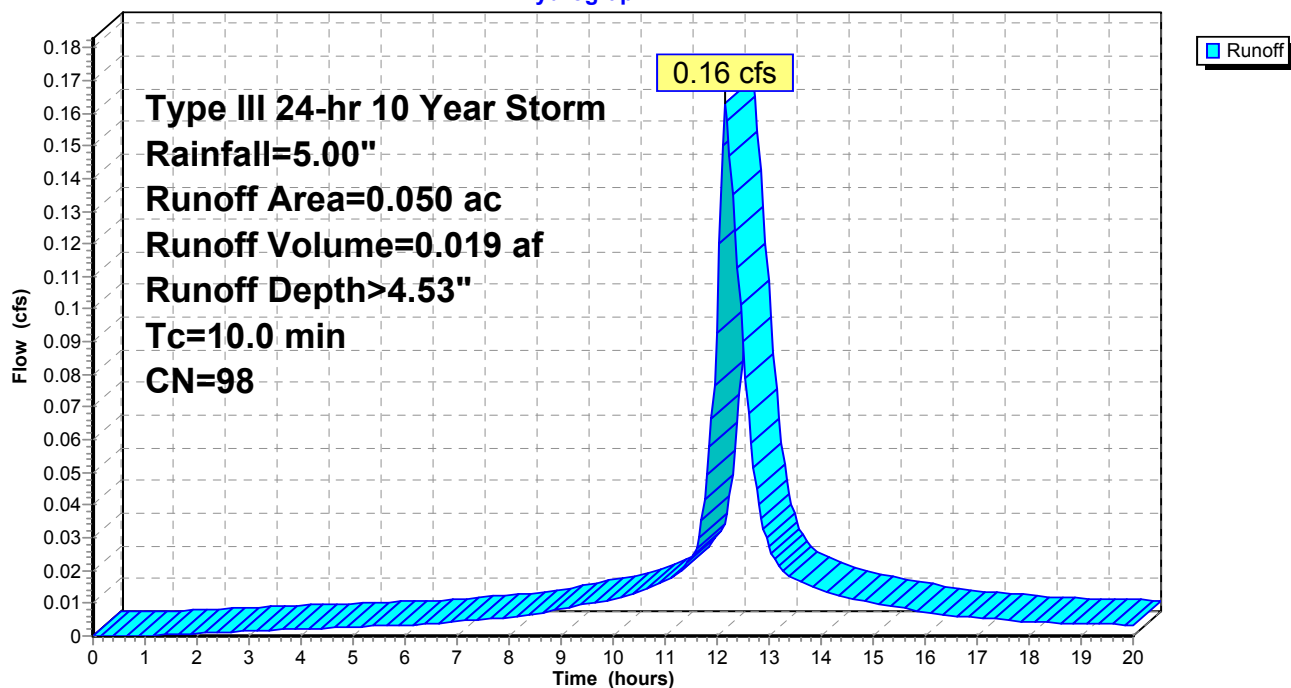
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 0.050	98	Impervious
0.050		100.00% Impervious Area

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

### Subcatchment 3S: Section 2 Impervious

Hydrograph



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### Summary for Subcatchment 4AS: Section 3 Pervious

Runoff = 3.05 cfs @ 12.25 hrs, Volume= 0.381 af, Depth> 0.93"

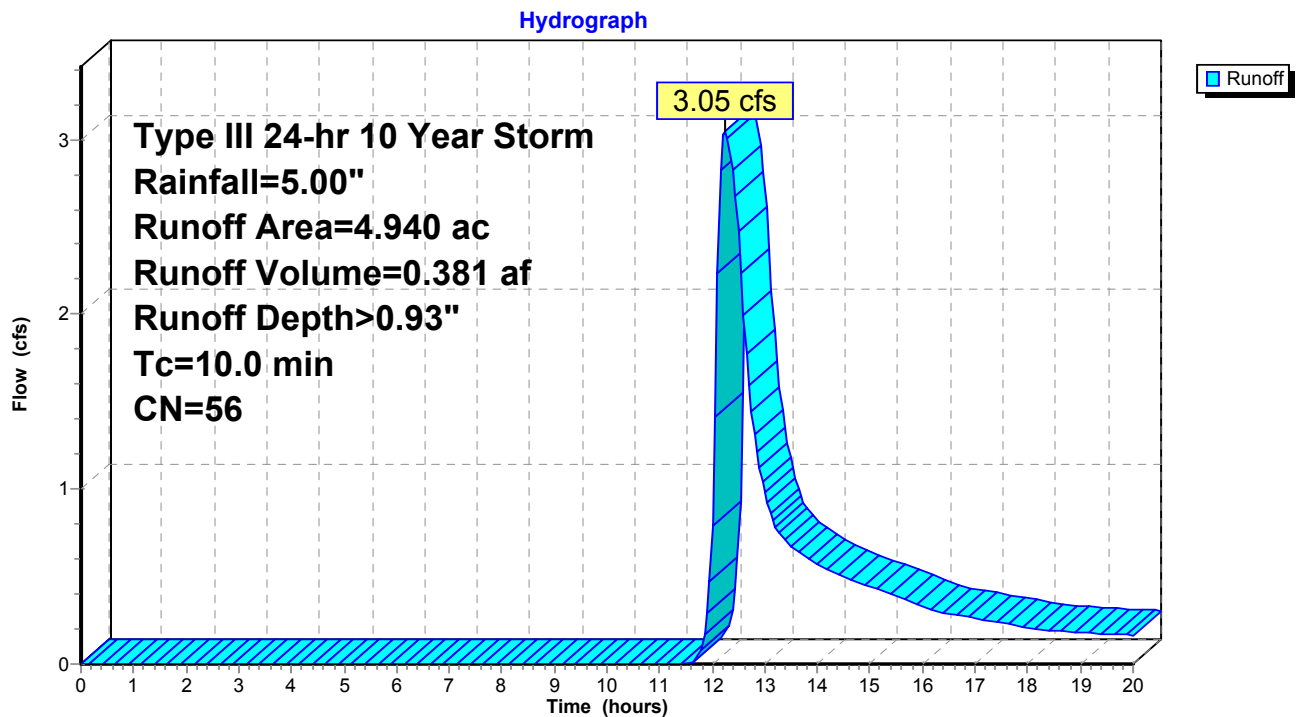
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 1.950	48	HSG B Brush
* 2.990	61	HSG B Grass
4.940	56	Weighted Average
4.940		100.00% Pervious Area

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

### Subcatchment 4AS: Section 3 Pervious





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### Summary for Subcatchment 4S: Section 3 Impervious

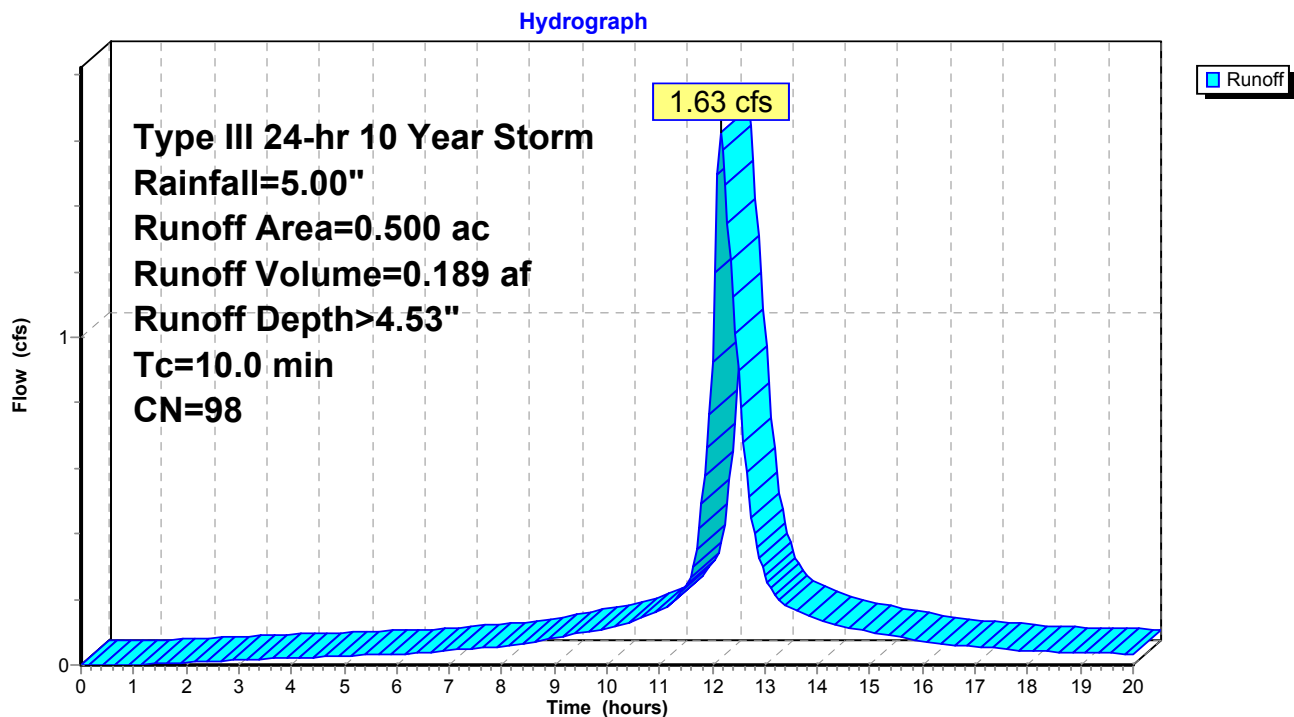
Runoff = 1.63 cfs @ 12.16 hrs, Volume= 0.189 af, Depth> 4.53"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 0.500	98	Impervious
0.500		100.00% Impervious Area

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

### Subcatchment 4S: Section 3 Impervious



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Type III 24-hr 10 Year Storm Rainfall=5.00"

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**Summary for Pond 5P: Basin**

Inflow Area = 18.560 ac, 20.74% Impervious, Inflow Depth > 1.90" for 10 Year Storm event  
 Inflow = 15.87 cfs @ 12.30 hrs, Volume= 2.939 af  
 Outflow = 4.54 cfs @ 13.85 hrs, Volume= 1.966 af, Atten= 71%, Lag= 93.0 min  
 Primary = 4.54 cfs @ 13.85 hrs, Volume= 1.966 af

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
 Peak Elev= 51.35' @ 13.85 hrs Surf.Area= 0 sf Storage= 64,104 cf

Plug-Flow detention time= 199.8 min calculated for 1.961 af (67% of inflow)  
 Center-of-Mass det. time= 118.6 min ( 913.8 - 795.2 )

Volume	Invert	Avail.Storage	Storage Description
#1	48.60'	192,588 cf	<b>Custom Stage Data</b> Listed below

Elevation (feet)	Cum.Store (cubic-feet)
48.60	0
49.00	678
50.00	14,156
51.00	47,136
52.00	96,280
53.00	154,720
53.60	192,588

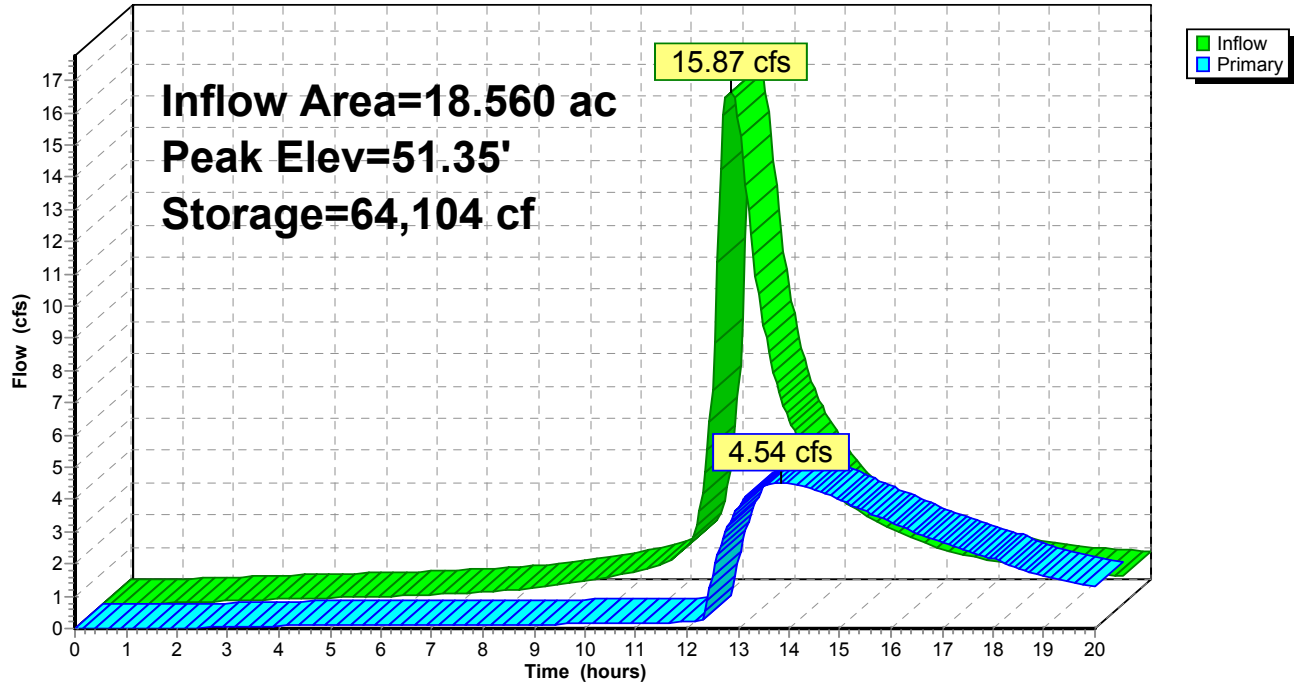
Device	Routing	Invert	Outlet Devices
#1	Primary	47.50'	<b>30.0" Round Culvert</b> L= 136.0' Ke= 0.600 Outlet Invert= 42.00' S= 0.0404 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	48.60'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Device 1	50.55'	<b>2.0' long Sharp-Crested Rectangular Weir</b> 2 End Contraction(s)
#4	Device 1	52.30'	<b>5.0' long Sharp-Crested Rectangular Weir</b> 2 End Contraction(s)

**Primary OutFlow** Max=4.54 cfs @ 13.85 hrs HW=51.35' (Free Discharge)

1=Culvert (Passes 4.54 cfs of 35.70 cfs potential flow)  
 2=Orifice/Grate (Orifice Controls 0.27 cfs @ 7.83 fps)  
 3=Sharp-Crested Rectangular Weir (Weir Controls 4.27 cfs @ 2.92 fps)  
 4=Sharp-Crested Rectangular Weir ( Controls 0.00 cfs)

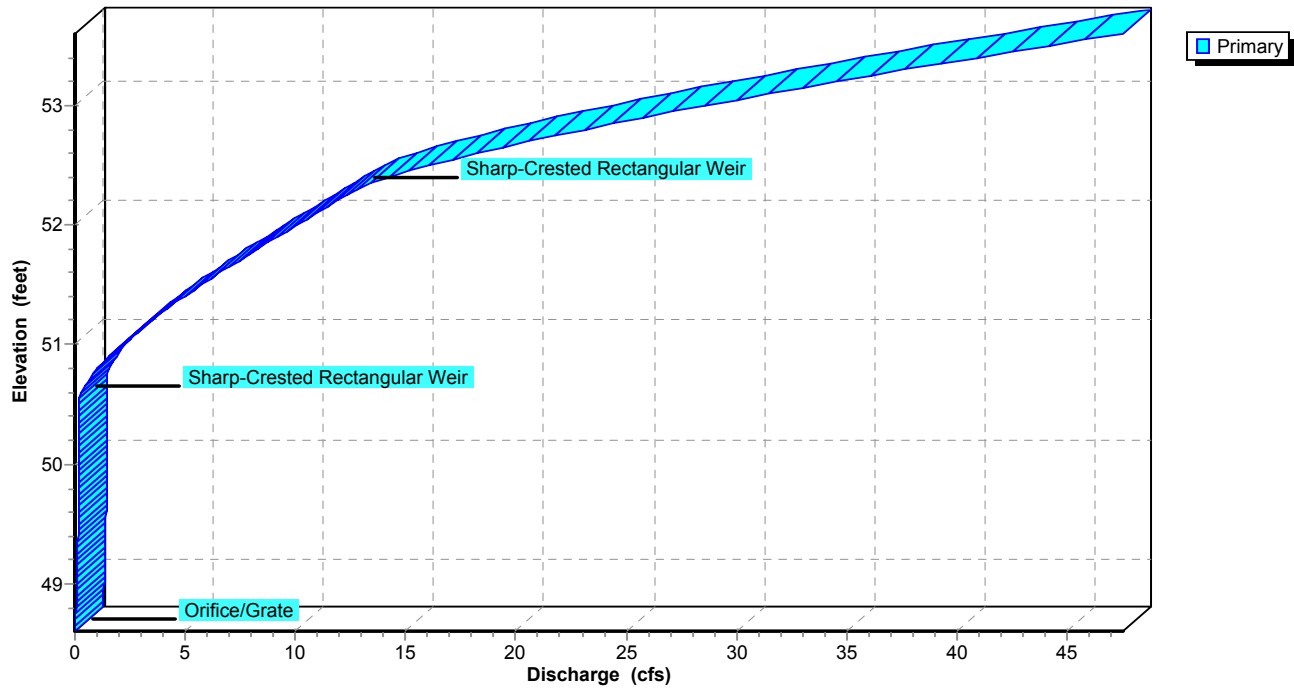
**Pond 5P: Basin**

**Hydrograph**



**Pond 5P: Basin**

**Stage-Discharge**



## Hamilton Estates Proposed

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Type III 24-hr 10 Year Storm Rainfall=5.00"

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### Summary for Link 6L: Total Site Flows

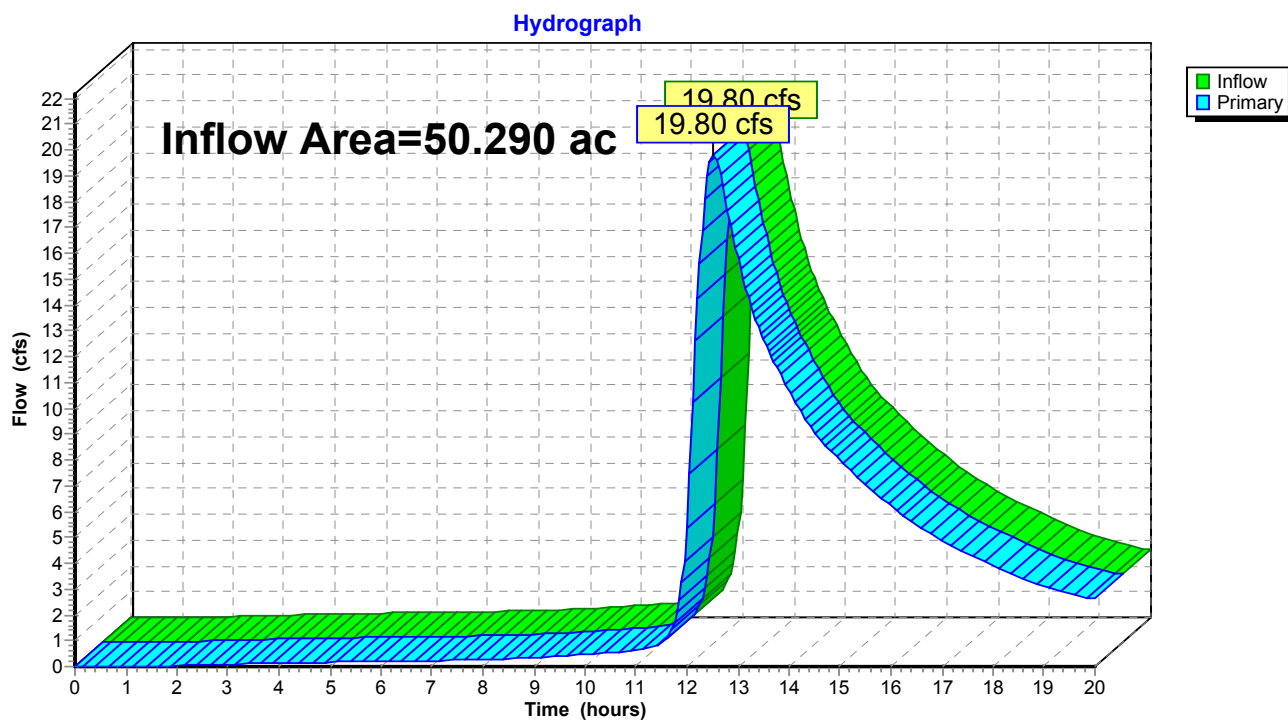
Revised to utilize Delmarva Unit Hydrograph.

Revised to route pervious and impervious areas separately.

Inflow Area = 50.290 ac, 10.44% Impervious, Inflow Depth > 1.29" for 10 Year Storm event  
Inflow = 19.80 cfs @ 12.52 hrs, Volume= 5.397 af  
Primary = 19.80 cfs @ 12.52 hrs, Volume= 5.397 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

### Link 6L: Total Site Flows



**Hamilton Estates Proposed***Type III 24-hr 100 Year Storm Rainfall=8.30"*

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Time span=0.00-20.00 hrs, dt=0.05 hrs, 401 points  
Runoff by SCS TR-20 method, UH=Delmarva  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

<b>Subcatchment 1AS: Routed Flows Pervious</b>	Runoff Area=14.710 ac 0.00% Impervious Runoff Depth>3.33" Tc=31.2 min CN=61 Runoff=23.10 cfs 4.087 af
<b>Subcatchment 1S: Routed Flows</b>	Runoff Area=3.850 ac 100.00% Impervious Runoff Depth>7.68" Tc=10.0 min CN=98 Runoff=20.95 cfs 2.463 af
<b>Subcatchment 2AS: Section 1 Pervious</b>	Runoff Area=24.290 ac 0.00% Impervious Runoff Depth>3.34" Tc=30.6 min CN=61 Runoff=38.56 cfs 6.751 af
<b>Subcatchment 2S: Section 1 Impervious</b>	Runoff Area=0.850 ac 100.00% Impervious Runoff Depth>7.68" Tc=10.0 min CN=98 Runoff=4.63 cfs 0.544 af
<b>Subcatchment 3AS: Section 2 Pervious</b>	Runoff Area=1.100 ac 0.00% Impervious Runoff Depth>2.51" Tc=10.0 min CN=53 Runoff=2.14 cfs 0.231 af
<b>Subcatchment 3S: Section 2 Impervious</b>	Runoff Area=0.050 ac 100.00% Impervious Runoff Depth>7.68" Tc=10.0 min CN=98 Runoff=0.27 cfs 0.032 af
<b>Subcatchment 4AS: Section 3 Pervious</b>	Runoff Area=4.940 ac 0.00% Impervious Runoff Depth>2.84" Tc=10.0 min CN=56 Runoff=11.05 cfs 1.167 af
<b>Subcatchment 4S: Section 3 Impervious</b>	Runoff Area=0.500 ac 100.00% Impervious Runoff Depth>7.68" Tc=10.0 min CN=98 Runoff=2.72 cfs 0.320 af
<b>Pond 5P: Basin</b>	Peak Elev=52.44' Storage=122,177 cf Inflow=36.46 cfs 6.550 af Outflow=15.01 cfs 5.345 af
<b>Link 6L: Total Site Flows</b>	Inflow=61.08 cfs 14.390 af Primary=61.08 cfs 14.390 af

**Total Runoff Area = 50.290 ac Runoff Volume = 15.595 af Average Runoff Depth = 3.72"**  
**89.56% Pervious = 45.040 ac 10.44% Impervious = 5.250 ac**

## Hamilton Estates Proposed

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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 1AS: Routed Flows Pervious

Runoff = 23.10 cfs @ 12.53 hrs, Volume= 4.087 af, Depth> 3.33"

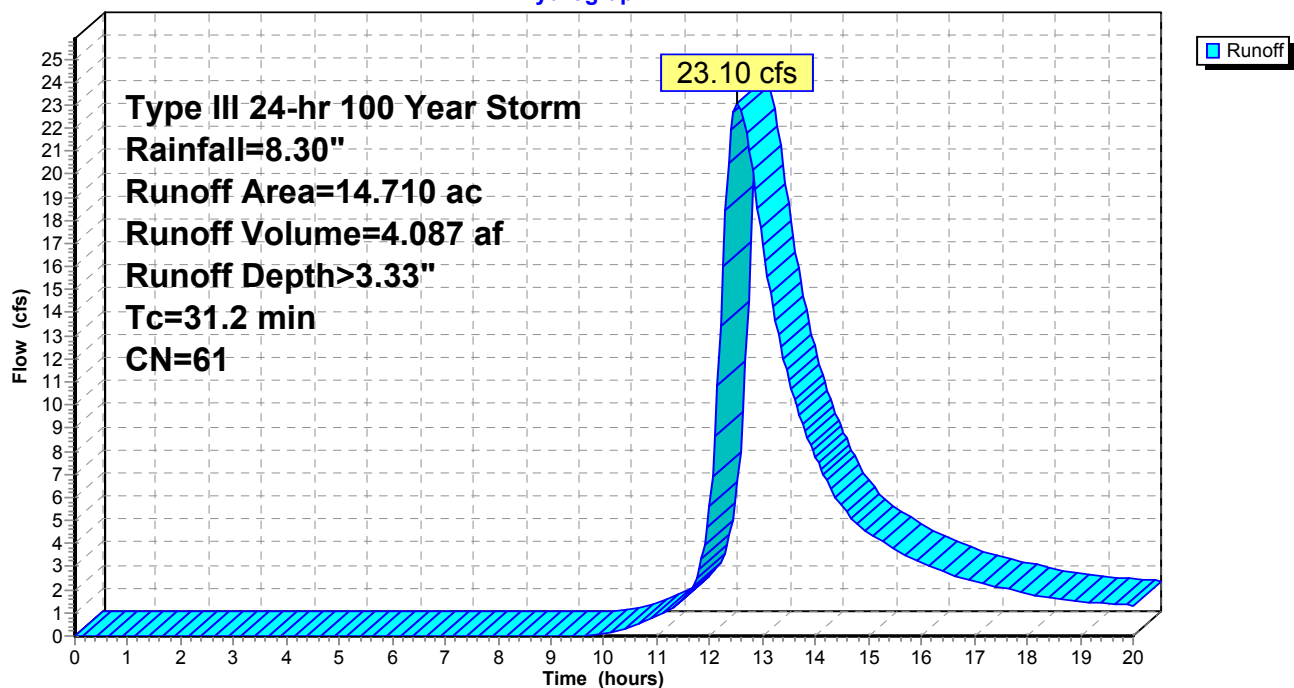
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 14.710	61	HSG B Open Space
14.710		100.00% Pervious Area

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

### Subcatchment 1AS: Routed Flows Pervious

Hydrograph



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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 1S: Routed Flows Impervious

Runoff = 20.95 cfs @ 12.16 hrs, Volume= 2.463 af, Depth> 7.68"

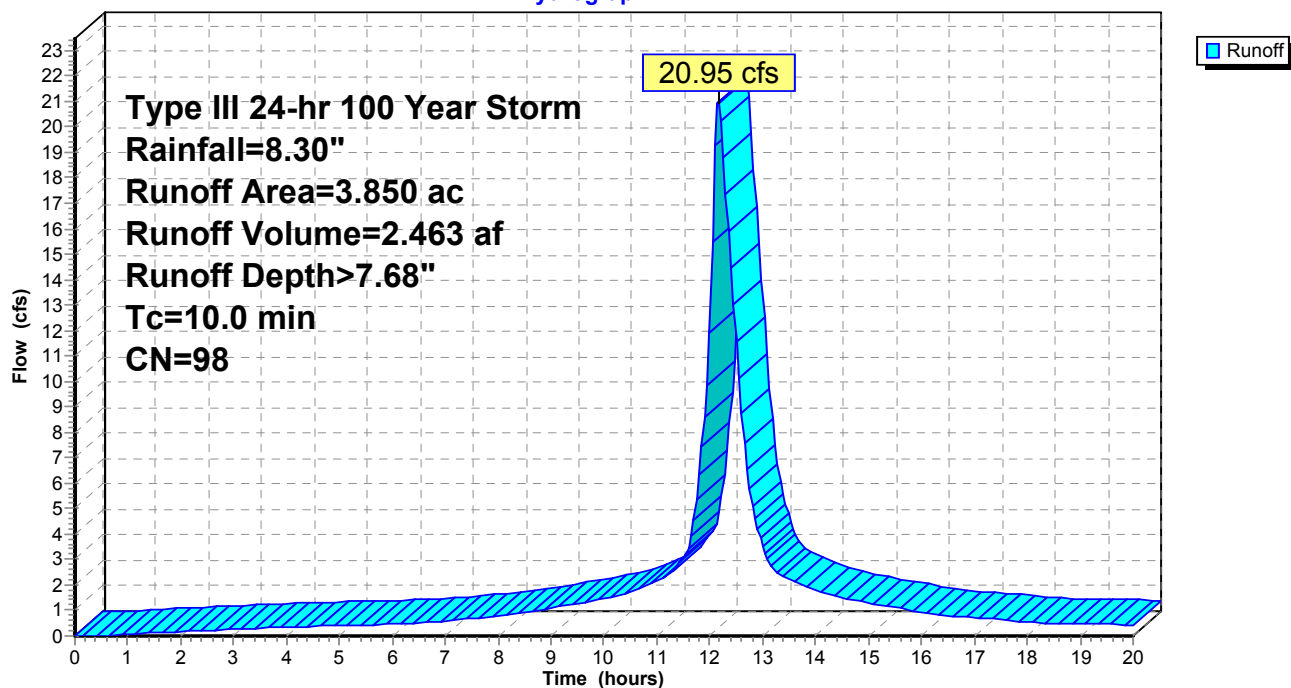
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 3.850	98	Impervious
3.850		100.00% Impervious Area

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

### Subcatchment 1S: Routed Flows Impervious

Hydrograph



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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 2AS: Section 1 Pervious

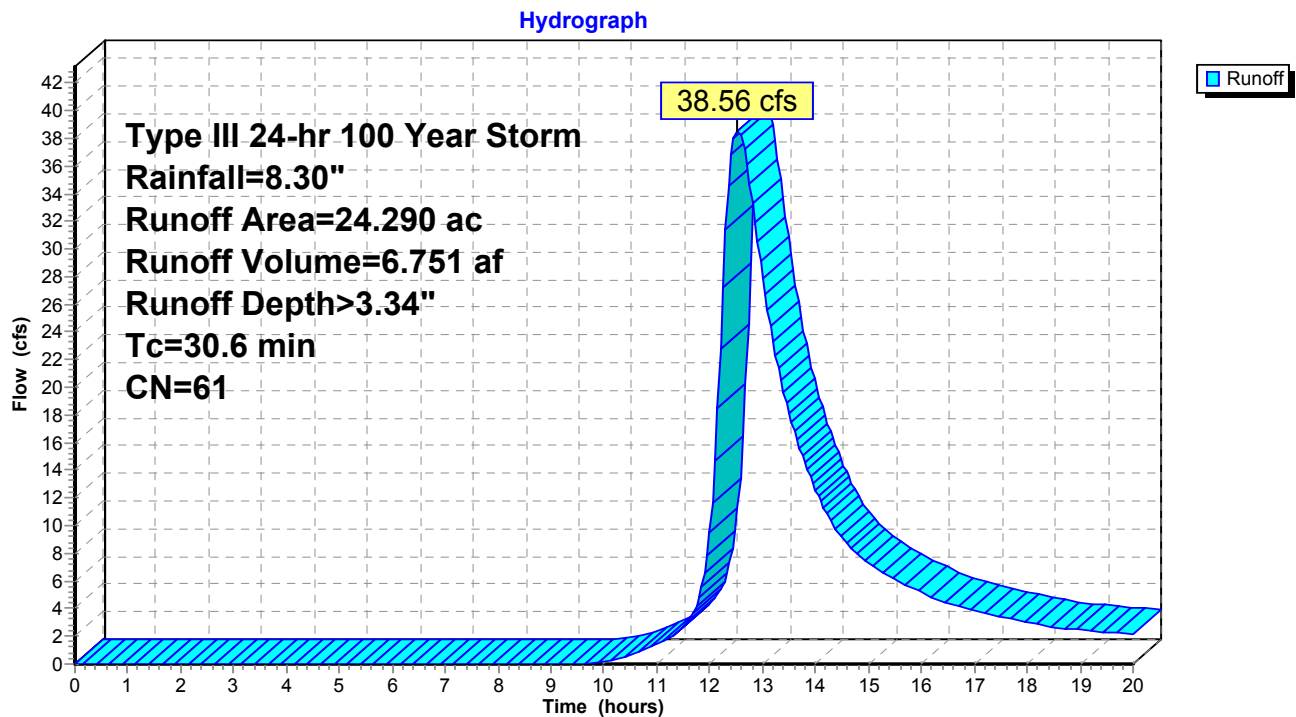
Runoff = 38.56 cfs @ 12.52 hrs, Volume= 6.751 af, Depth> 3.34"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 22.790	61	HSG B Open Space
* 1.500	55	HSG B Woods
24.290	61	Weighted Average
24.290		100.00% Pervious Area

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

### Subcatchment 2AS: Section 1 Pervious





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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 2S: Section 1 Impervious

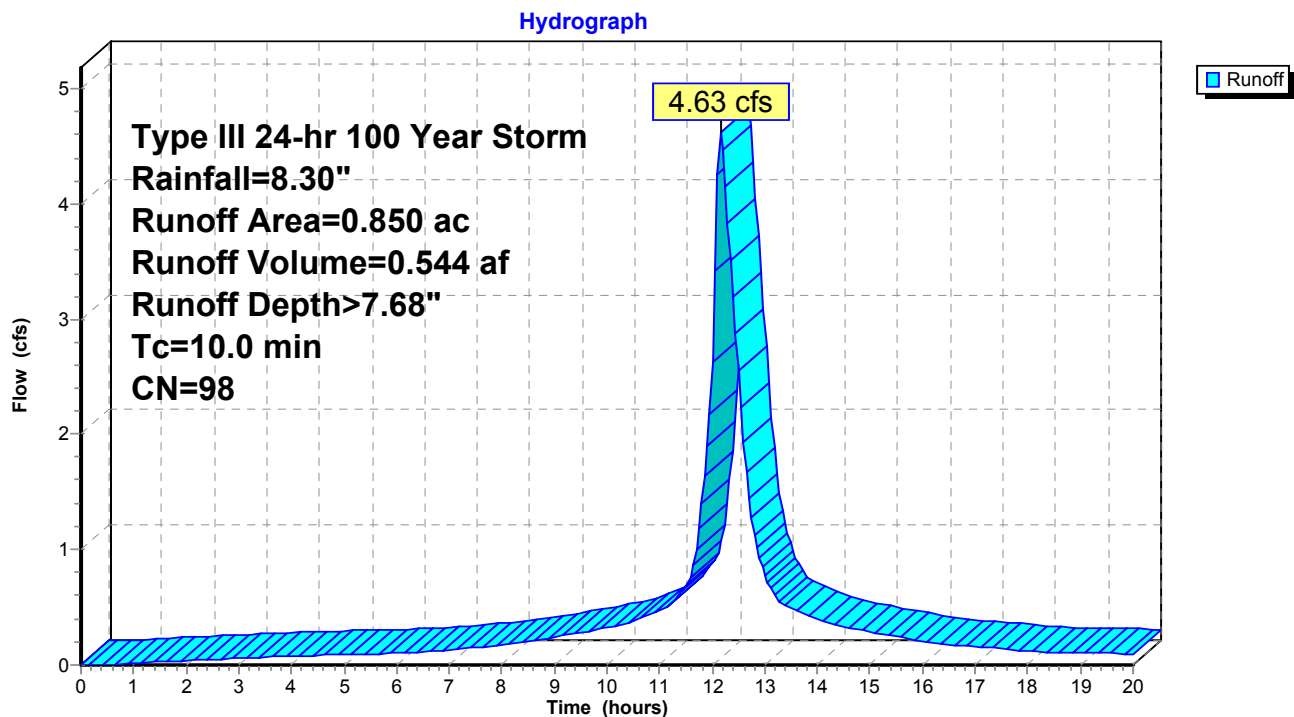
Runoff = 4.63 cfs @ 12.16 hrs, Volume= 0.544 af, Depth> 7.68"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 0.850	98	Impervious
0.850		100.00% Impervious Area

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

### Subcatchment 2S: Section 1 Impervious



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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 3AS: Section 2 Pervious

Runoff = 2.14 cfs @ 12.20 hrs, Volume= 0.231 af, Depth> 2.51"

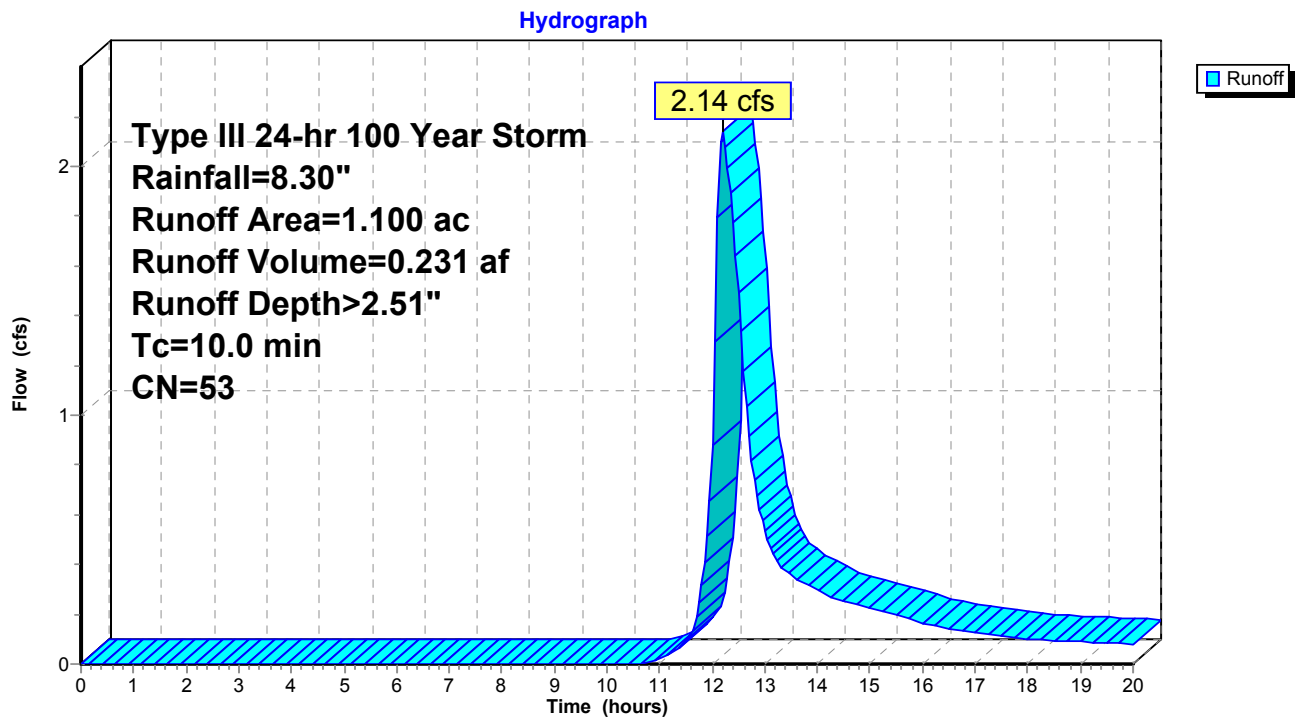
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 0.670	48	HSG B Brush
* 0.430	61	HSG B Open Space
1.100	53	Weighted Average
1.100		100.00% Pervious Area

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

### Subcatchment 3AS: Section 2 Pervious



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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 3S: Section 2 Impervious

Runoff = 0.27 cfs @ 12.16 hrs, Volume= 0.032 af, Depth> 7.68"

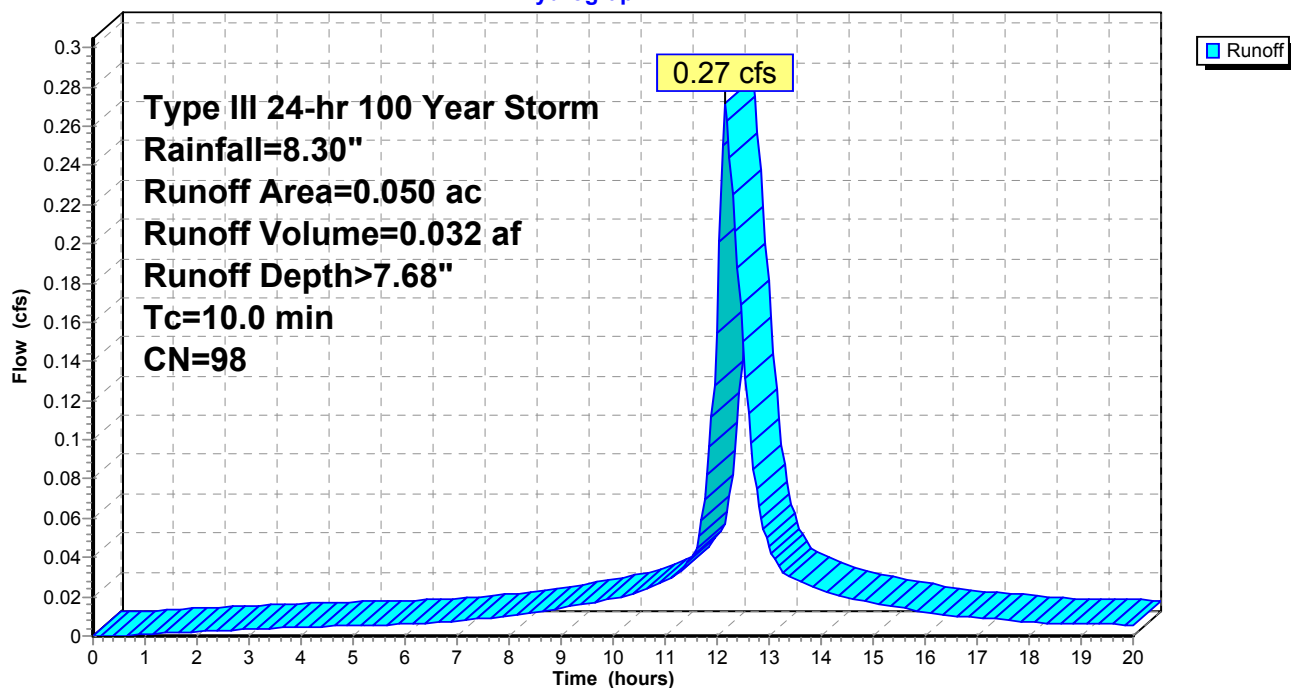
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 0.050	98	Impervious
0.050		100.00% Impervious Area

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

### Subcatchment 3S: Section 2 Impervious

Hydrograph



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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 4AS: Section 3 Pervious

Runoff = 11.05 cfs @ 12.19 hrs, Volume= 1.167 af, Depth> 2.84"

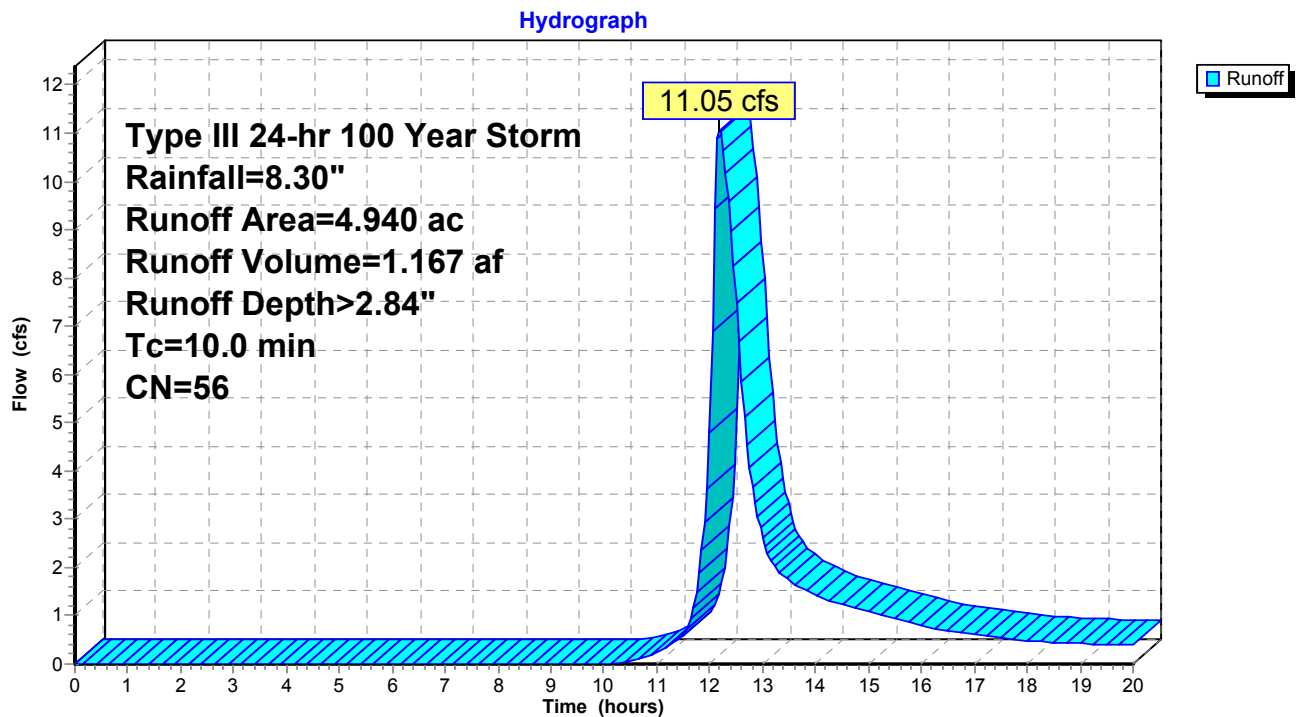
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 1.950	48	HSG B Brush
* 2.990	61	HSG B Grass
4.940	56	Weighted Average
4.940		100.00% Pervious Area

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

### Subcatchment 4AS: Section 3 Pervious



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Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 4S: Section 3 Impervious

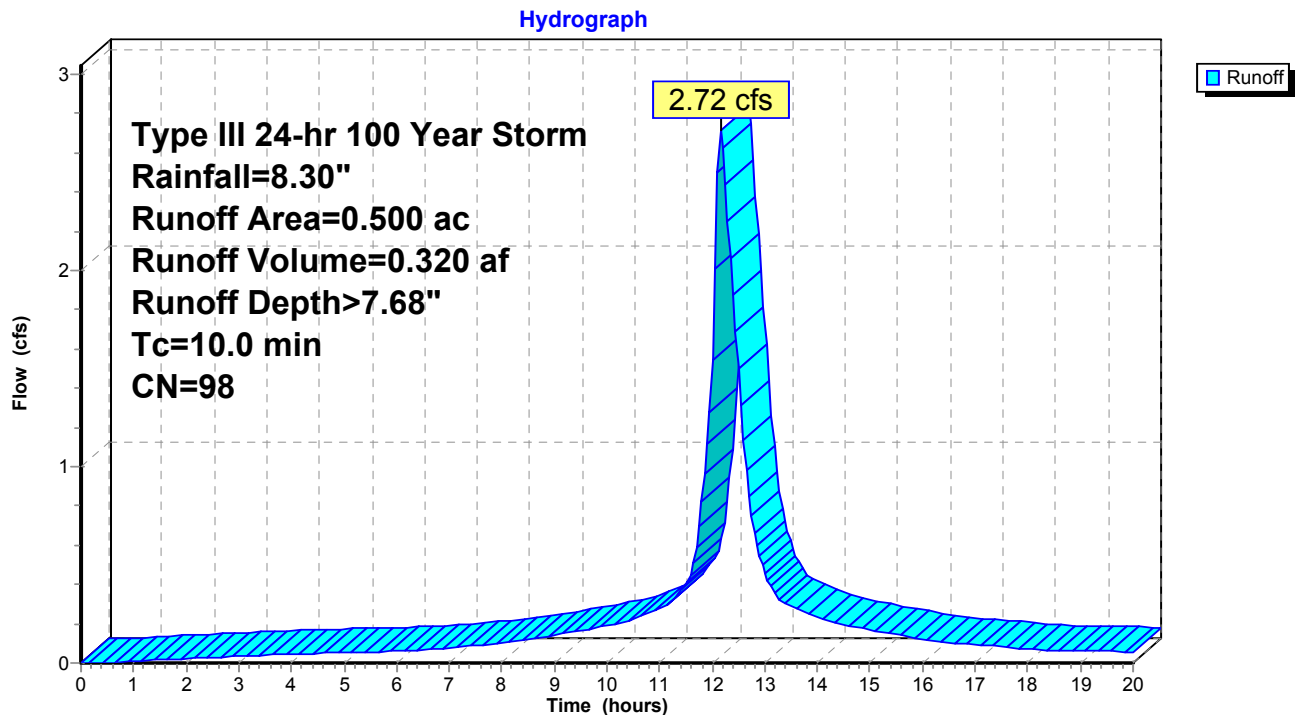
Runoff = 2.72 cfs @ 12.16 hrs, Volume= 0.320 af, Depth> 7.68"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 0.500	98	Impervious
0.500		100.00% Impervious Area

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

### Subcatchment 4S: Section 3 Impervious



**Hamilton Estates Proposed**

Type III 24-hr 100 Year Storm Rainfall=8.30"

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**Summary for Pond 5P: Basin**

Inflow Area = 18.560 ac, 20.74% Impervious, Inflow Depth > 4.23" for 100 Year Storm event  
 Inflow = 36.46 cfs @ 12.37 hrs, Volume= 6.550 af  
 Outflow = 15.01 cfs @ 13.34 hrs, Volume= 5.345 af, Atten= 59%, Lag= 58.2 min  
 Primary = 15.01 cfs @ 13.34 hrs, Volume= 5.345 af

Routing by Stor-Ind method, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs  
 Peak Elev= 52.44' @ 13.34 hrs Surf.Area= 0 sf Storage= 122,177 cf

Plug-Flow detention time= 154.2 min calculated for 5.345 af (82% of inflow)  
 Center-of-Mass det. time= 102.3 min ( 897.0 - 794.6 )

Volume	Invert	Avail.Storage	Storage Description
#1	48.60'	192,588 cf	<b>Custom Stage Data</b> Listed below

Elevation (feet)	Cum.Store (cubic-feet)
48.60	0
49.00	678
50.00	14,156
51.00	47,136
52.00	96,280
53.00	154,720
53.60	192,588

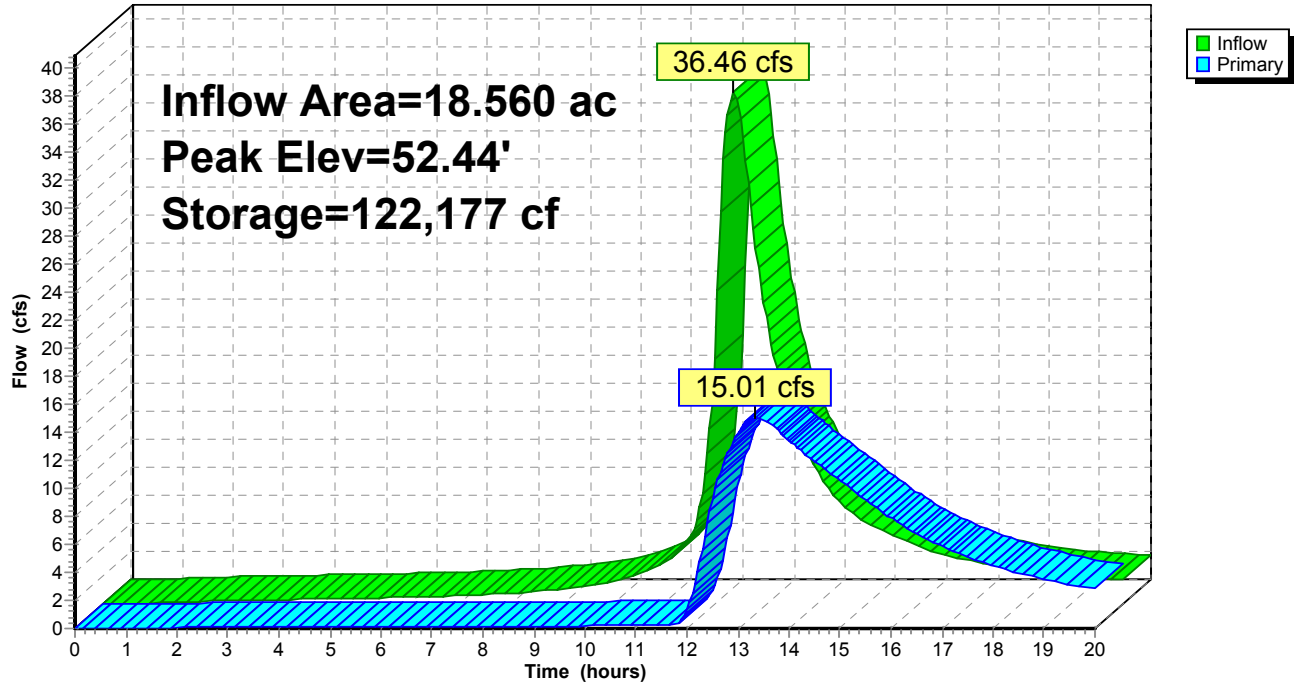
Device	Routing	Invert	Outlet Devices
#1	Primary	47.50'	<b>30.0" Round Culvert</b> L= 136.0' Ke= 0.600 Outlet Invert= 42.00' S= 0.0404 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	48.60'	<b>2.5" Vert. Orifice/Grate</b> C= 0.600
#3	Device 1	50.55'	<b>2.0' long Sharp-Crested Rectangular Weir</b> 2 End Contraction(s)
#4	Device 1	52.30'	<b>5.0' long Sharp-Crested Rectangular Weir</b> 2 End Contraction(s)

**Primary OutFlow** Max=15.01 cfs @ 13.34 hrs HW=52.44' (Free Discharge)

↑ **1=Culvert** (Passes 15.01 cfs of 42.58 cfs potential flow)  
 ↑ **2=Orifice/Grate** (Orifice Controls 0.32 cfs @ 9.31 fps)  
 ↑ **3=Sharp-Crested Rectangular Weir** (Weir Controls 13.81 cfs @ 4.50 fps)  
 ↑ **4=Sharp-Crested Rectangular Weir** (Weir Controls 0.88 cfs @ 1.24 fps)

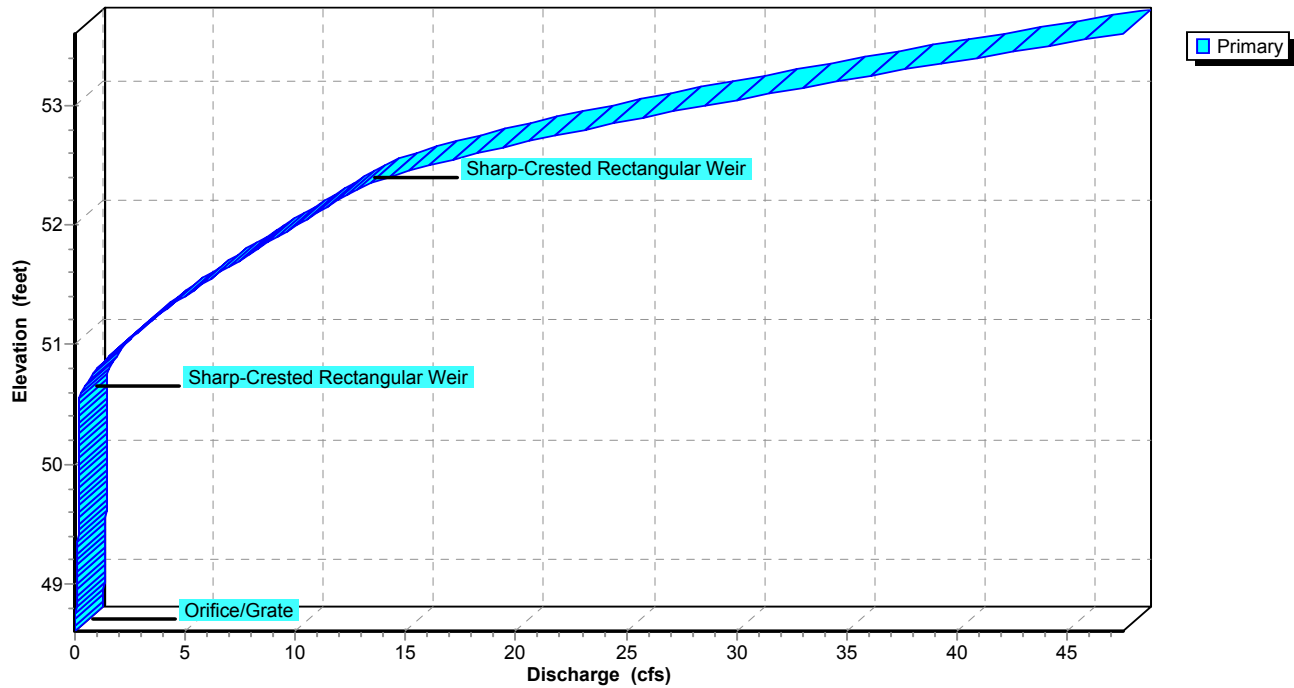
**Pond 5P: Basin**

Hydrograph



**Pond 5P: Basin**

Stage-Discharge



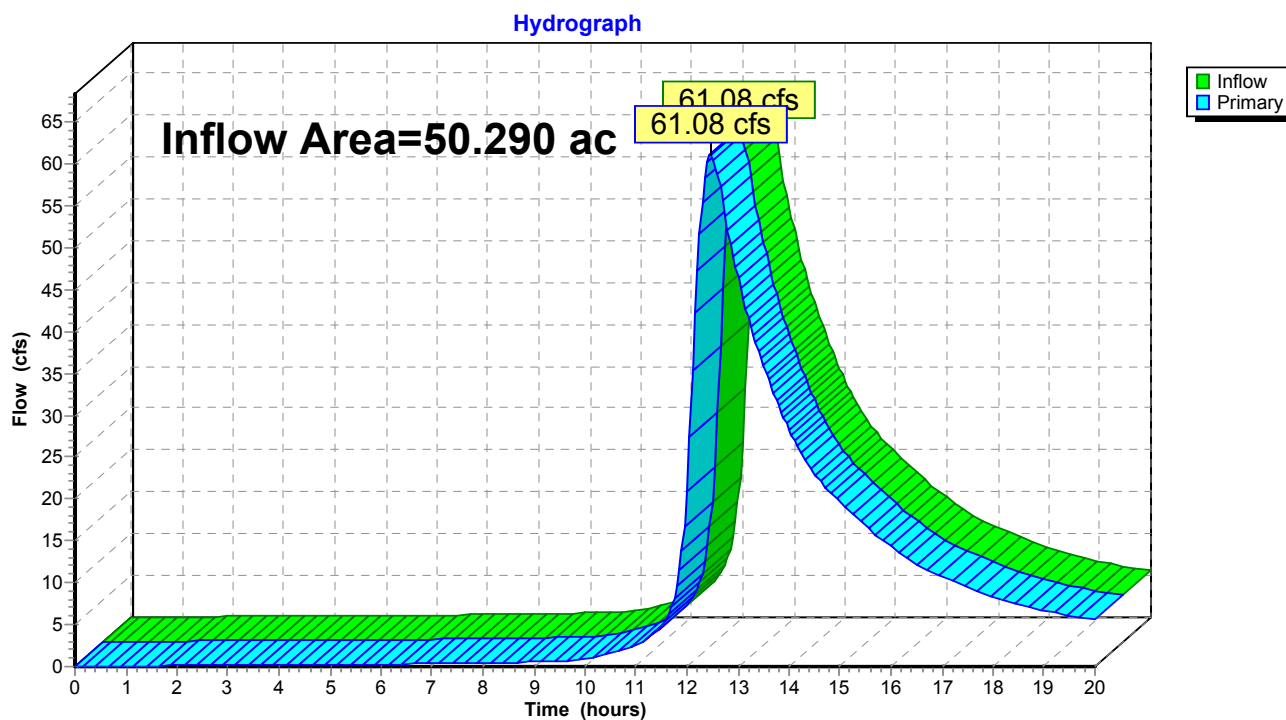
**Summary for Link 6L: Total Site Flows**

Revised to utilize Delmarva Unit Hydrograph.

Revised to route pervious and impervious areas separately.

Inflow Area = 50.290 ac, 10.44% Impervious, Inflow Depth > 3.43" for 100 Year Storm event  
Inflow = 61.08 cfs @ 12.47 hrs, Volume= 14.390 af  
Primary = 61.08 cfs @ 12.47 hrs, Volume= 14.390 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-20.00 hrs, dt= 0.05 hrs

**Link 6L: Total Site Flows**

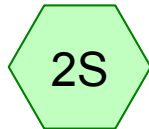


## ATTACHMENT B

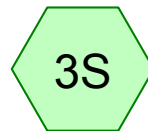
### COMPARISON OF RUNOFF FROM VARIOUS LAND COVERS



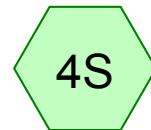
Woods



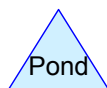
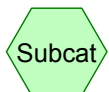
Small Grain



Meadow



Brush



**Drainage Diagram for Hamilton Estates Land Cover Comparison**

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## Hamilton Estates Land Cover Comparison

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### Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.620	48	Brush (4S)
2.620	55	Woods (1S)
2.620	58	Meadow (3S)
2.620	72	Small Grain (2S)
<b>10.480</b>		<b>TOTAL AREA</b>

## Hamilton Estates Land Cover Comparison

Type III 24-hr 2 Year Storm Rainfall=3.30"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=Delmarva

Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

### Subcatchment1S: Woods

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>0.23"  
Tc=33.0 min CN=55 Runoff=0.15 cfs 0.050 af

### Subcatchment2S: Small Grain

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>0.88"  
Tc=33.0 min CN=72 Runoff=0.99 cfs 0.192 af

### Subcatchment3S: Meadow

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>0.31"  
Tc=33.0 min CN=58 Runoff=0.24 cfs 0.068 af

### Subcatchment4S: Brush

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>0.08"  
Tc=33.0 min CN=48 Runoff=0.04 cfs 0.017 af

**Total Runoff Area = 10.480 ac Runoff Volume = 0.327 af Average Runoff Depth = 0.37"**  
**100.00% Pervious = 10.480 ac 0.00% Impervious = 0.000 ac**

## Hamilton Estates Land Cover Comparison

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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 1S: Woods

Runoff = 0.15 cfs @ 12.89 hrs, Volume= 0.050 af, Depth> 0.23"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

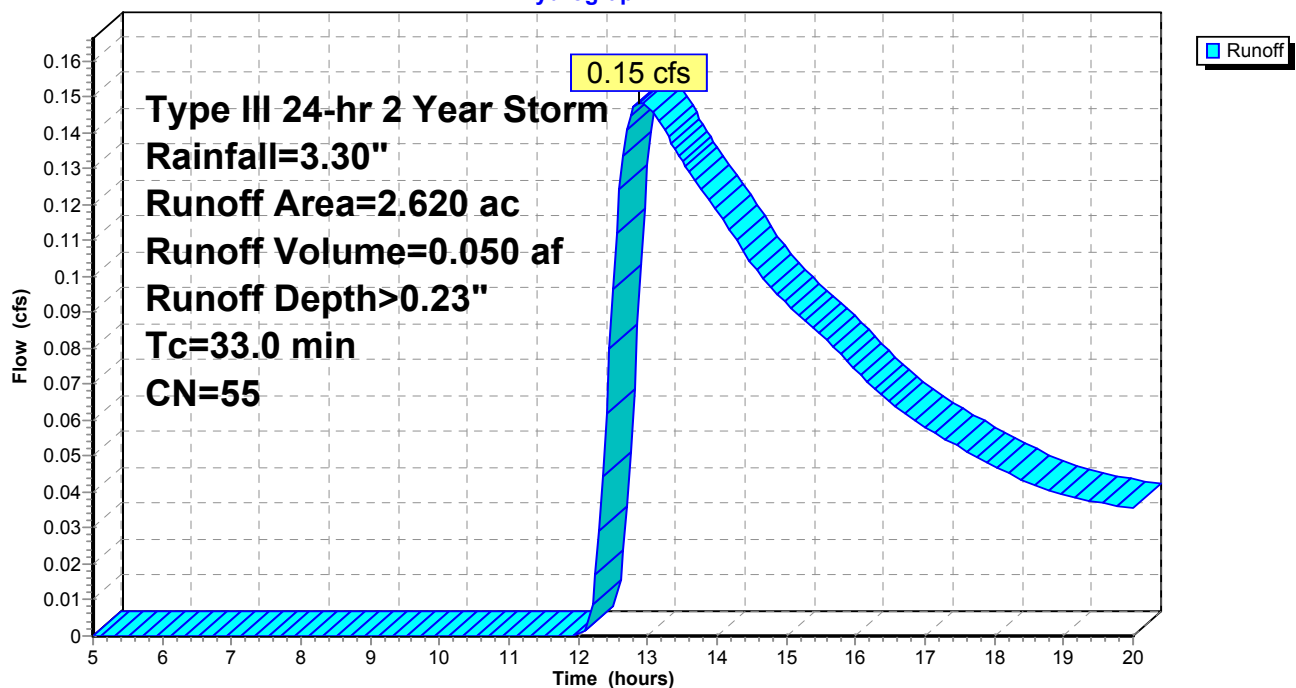
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 2.620	55	Woods
2.620		100.00% Pervious Area

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

### Subcatchment 1S: Woods

Hydrograph



## Hamilton Estates Land Cover Comparison

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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 2S: Small Grain

Runoff = 0.99 cfs @ 12.60 hrs, Volume= 0.192 af, Depth> 0.88"

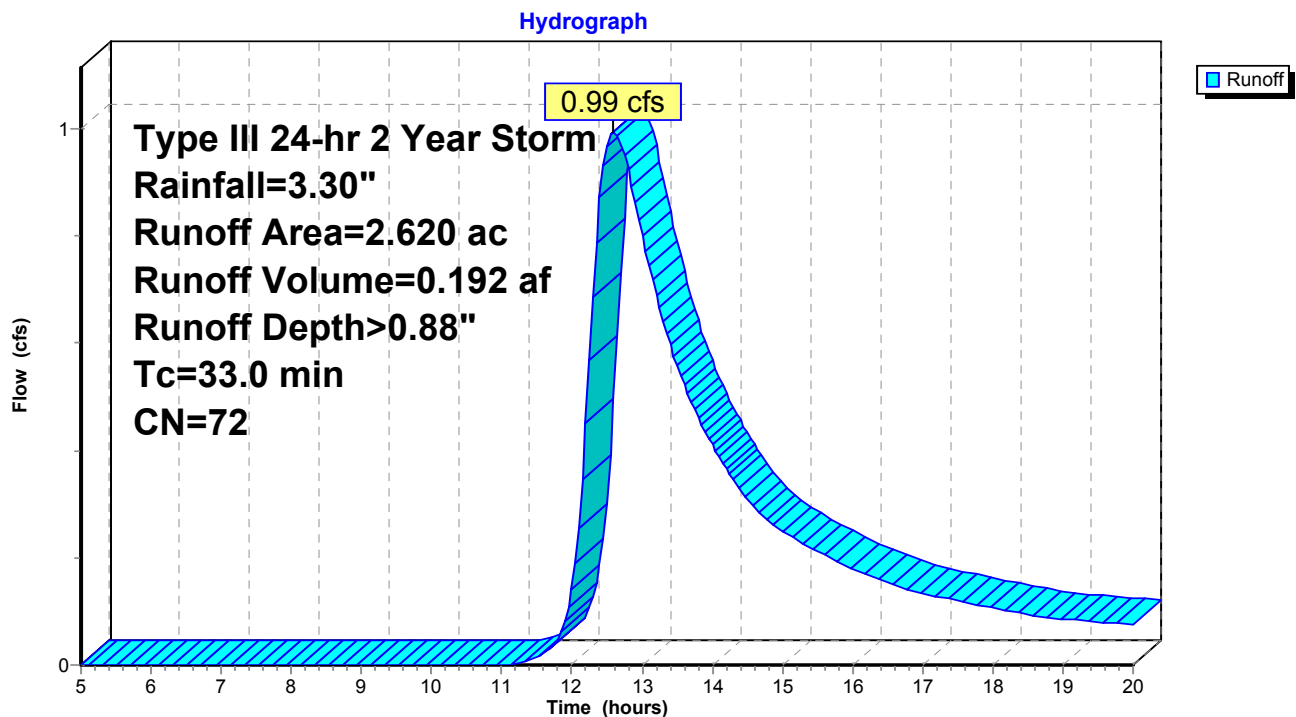
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 2.620	72	Small Grain
2.620		100.00% Pervious Area

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

### Subcatchment 2S: Small Grain



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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 3S: Meadow

Runoff = 0.24 cfs @ 12.77 hrs, Volume= 0.068 af, Depth> 0.31"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

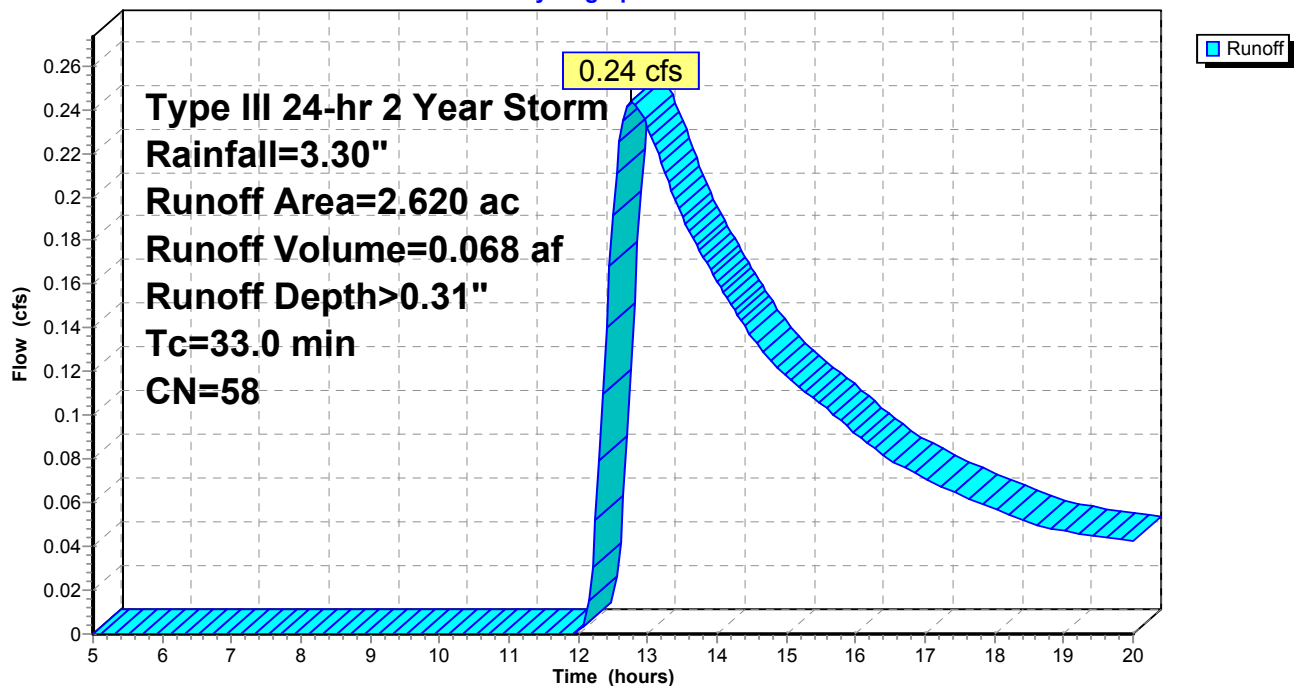
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 2.620	58	Meadow
2.620		100.00% Pervious Area

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

### Subcatchment 3S: Meadow

Hydrograph



## Hamilton Estates Land Cover Comparison

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Type III 24-hr 2 Year Storm Rainfall=3.30"

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### Summary for Subcatchment 4S: Brush

Runoff = 0.04 cfs @ 15.03 hrs, Volume= 0.017 af, Depth> 0.08"

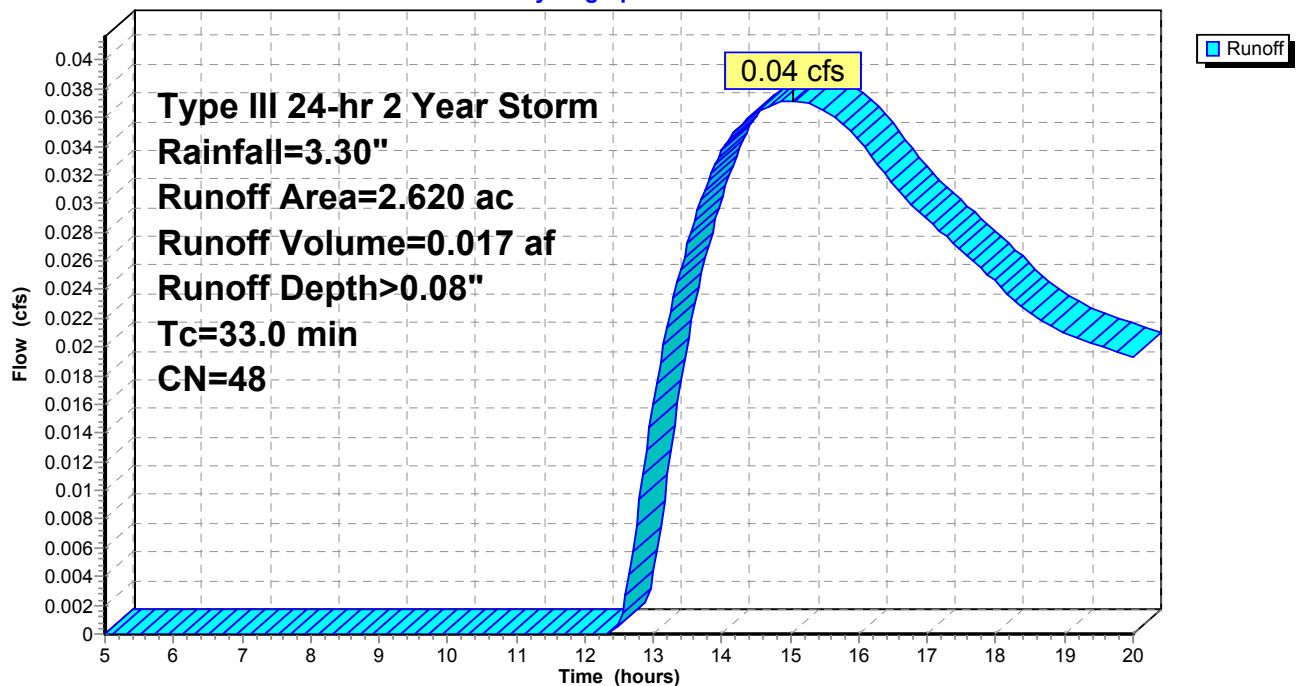
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2 Year Storm Rainfall=3.30"

Area (ac)	CN	Description
* 2.620	48	Brush
2.620		100.00% Pervious Area

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

### Subcatchment 4S: Brush

Hydrograph





## Hamilton Estates Land Cover Comparison

Type III 24-hr 10 Year Storm Rainfall=5.00"

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Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points

Runoff by SCS TR-20 method, UH=Delmarva

Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

### Subcatchment1S: Woods

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>0.85"  
Tc=33.0 min CN=55 Runoff=0.84 cfs 0.185 af

### Subcatchment2S: Small Grain

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>1.99"  
Tc=33.0 min CN=72 Runoff=2.38 cfs 0.435 af

### Subcatchment3S: Meadow

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>1.02"  
Tc=33.0 min CN=58 Runoff=1.08 cfs 0.223 af

### Subcatchment4S: Brush

Runoff Area=2.620 ac 0.00% Impervious Runoff Depth>0.49"  
Tc=33.0 min CN=48 Runoff=0.39 cfs 0.107 af

**Total Runoff Area = 10.480 ac Runoff Volume = 0.950 af Average Runoff Depth = 1.09"**  
**100.00% Pervious = 10.480 ac 0.00% Impervious = 0.000 ac**

## Hamilton Estates Land Cover Comparison

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Type III 24-hr 10 Year Storm Rainfall=5.00"

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### Summary for Subcatchment 1S: Woods

Runoff = 0.84 cfs @ 12.67 hrs, Volume= 0.185 af, Depth> 0.85"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

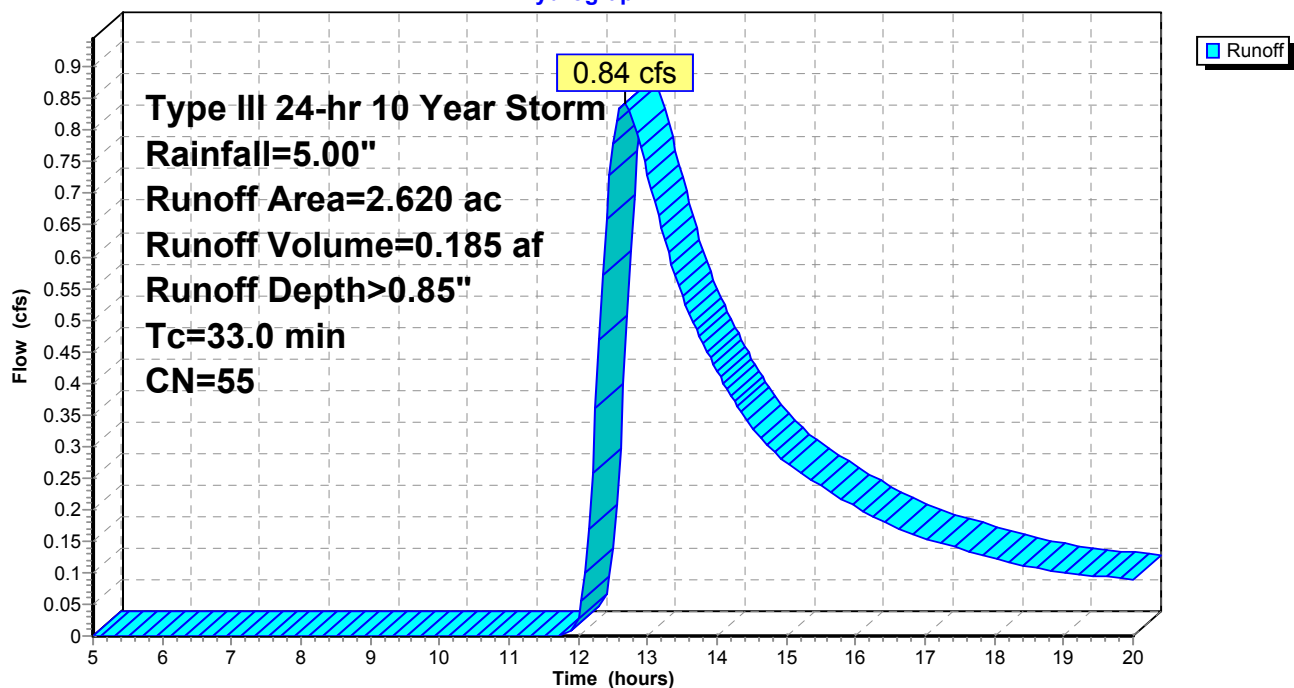
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 2.620	55	Woods
2.620		100.00% Pervious Area

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

### Subcatchment 1S: Woods

Hydrograph



## Hamilton Estates Land Cover Comparison

Type III 24-hr 10 Year Storm Rainfall=5.00"

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### Summary for Subcatchment 2S: Small Grain

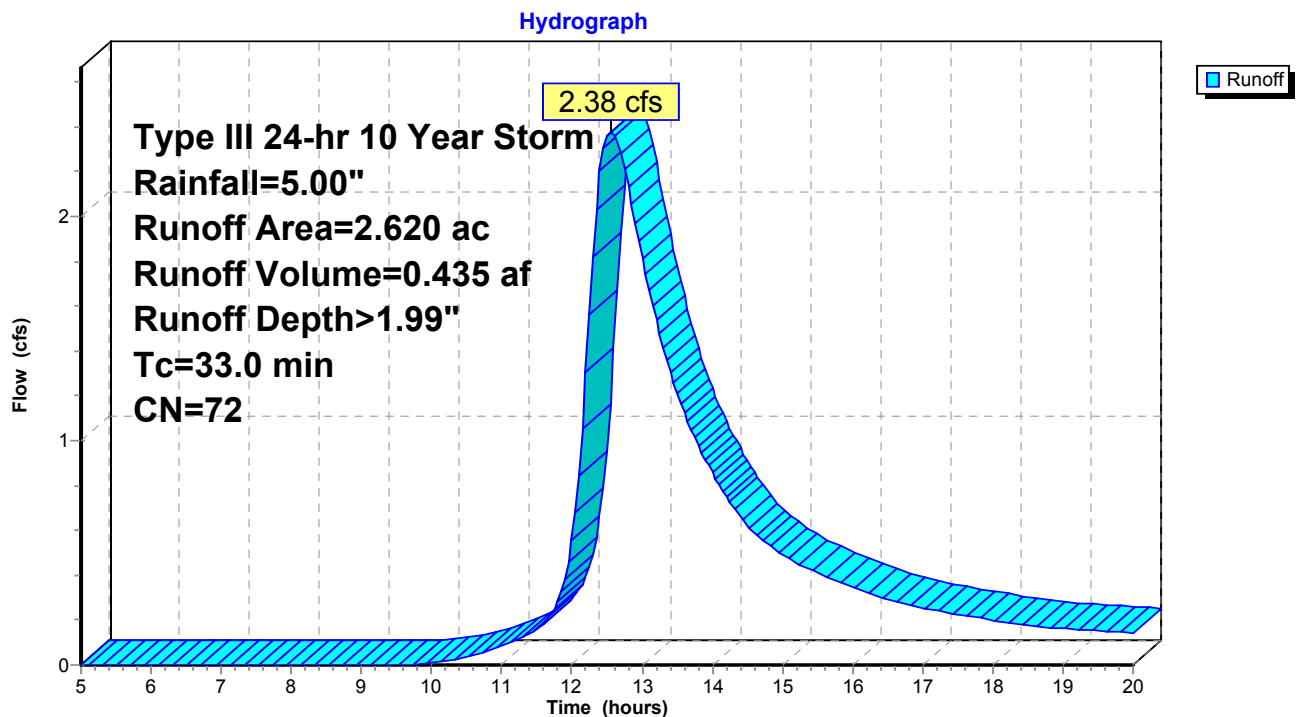
Runoff = 2.38 cfs @ 12.56 hrs, Volume= 0.435 af, Depth> 1.99"

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

Area (ac)	CN	Description
* 2.620	72	Small Grain
2.620		100.00% Pervious Area

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

### Subcatchment 2S: Small Grain



## Hamilton Estates Land Cover Comparison

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Type III 24-hr 10 Year Storm Rainfall=5.00"

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### Summary for Subcatchment 3S: Meadow

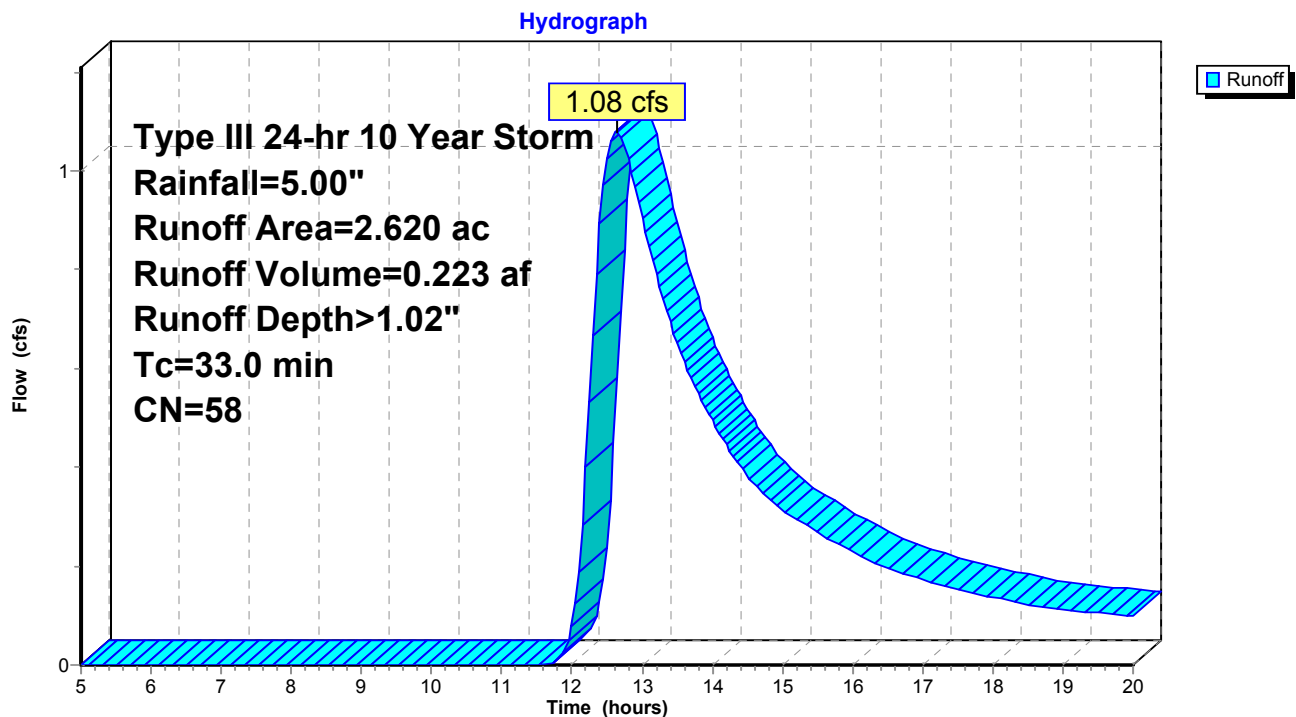
Runoff = 1.08 cfs @ 12.64 hrs, Volume= 0.223 af, Depth> 1.02"

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

Area (ac)	CN	Description
* 2.620	58	Meadow
2.620		100.00% Pervious Area

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

### Subcatchment 3S: Meadow



## Hamilton Estates Land Cover Comparison

Type III 24-hr 10 Year Storm Rainfall=5.00"

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### Summary for Subcatchment 4S: Brush

Runoff = 0.39 cfs @ 12.76 hrs, Volume= 0.107 af, Depth> 0.49"

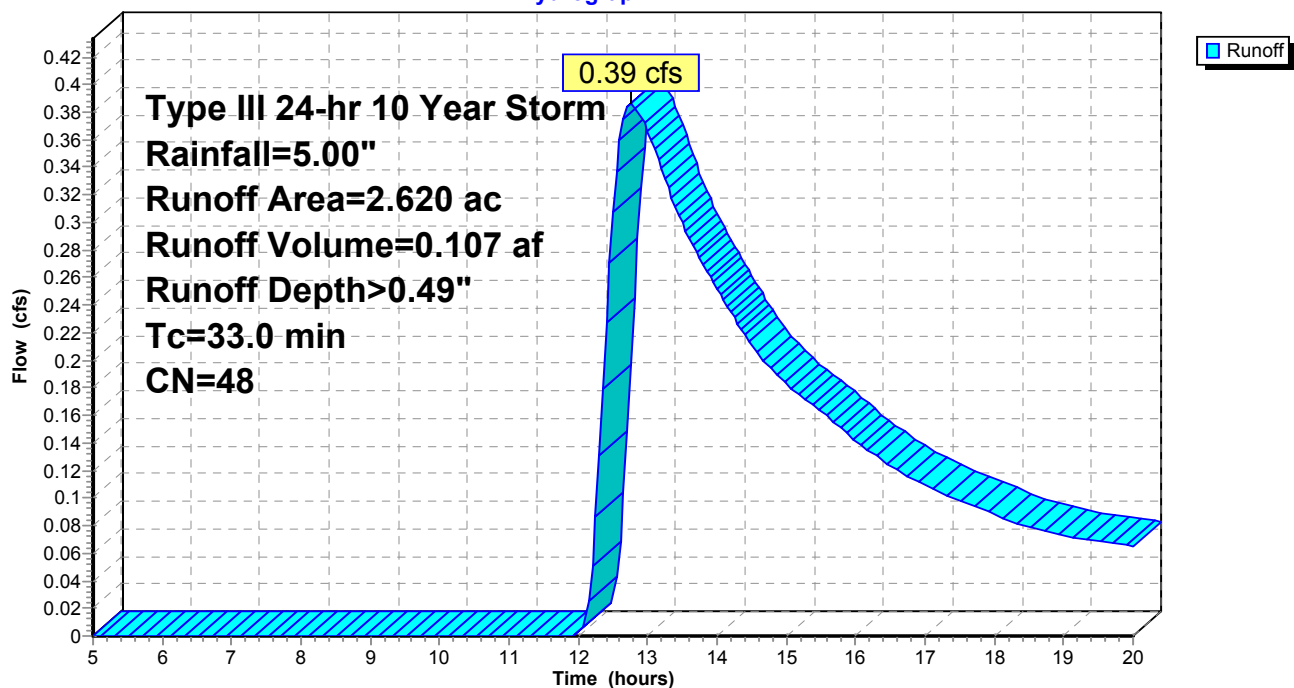
Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10 Year Storm Rainfall=5.00"

Area (ac)	CN	Description
* 2.620	48	Brush
2.620		100.00% Pervious Area

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

### Subcatchment 4S: Brush

Hydrograph



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

<b>Subcatchment1S: Woods</b>	Runoff Area=2.620 ac   0.00% Impervious   Runoff Depth>2.68" Tc=33.0 min   CN=55   Runoff=3.13 cfs   0.585 af
<b>Subcatchment2S: Small Grain</b>	Runoff Area=2.620 ac   0.00% Impervious   Runoff Depth>4.56" Tc=33.0 min   CN=72   Runoff=5.51 cfs   0.996 af
<b>Subcatchment3S: Meadow</b>	Runoff Area=2.620 ac   0.00% Impervious   Runoff Depth>3.00" Tc=33.0 min   CN=58   Runoff=3.56 cfs   0.656 af
<b>Subcatchment4S: Brush</b>	Runoff Area=2.620 ac   0.00% Impervious   Runoff Depth>1.95" Tc=33.0 min   CN=48   Runoff=2.14 cfs   0.427 af

**Total Runoff Area = 10.480 ac   Runoff Volume = 2.664 af   Average Runoff Depth = 3.05"**  
**100.00% Pervious = 10.480 ac   0.00% Impervious = 0.000 ac**

## Hamilton Estates Land Cover Comparison

Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 1S: Woods

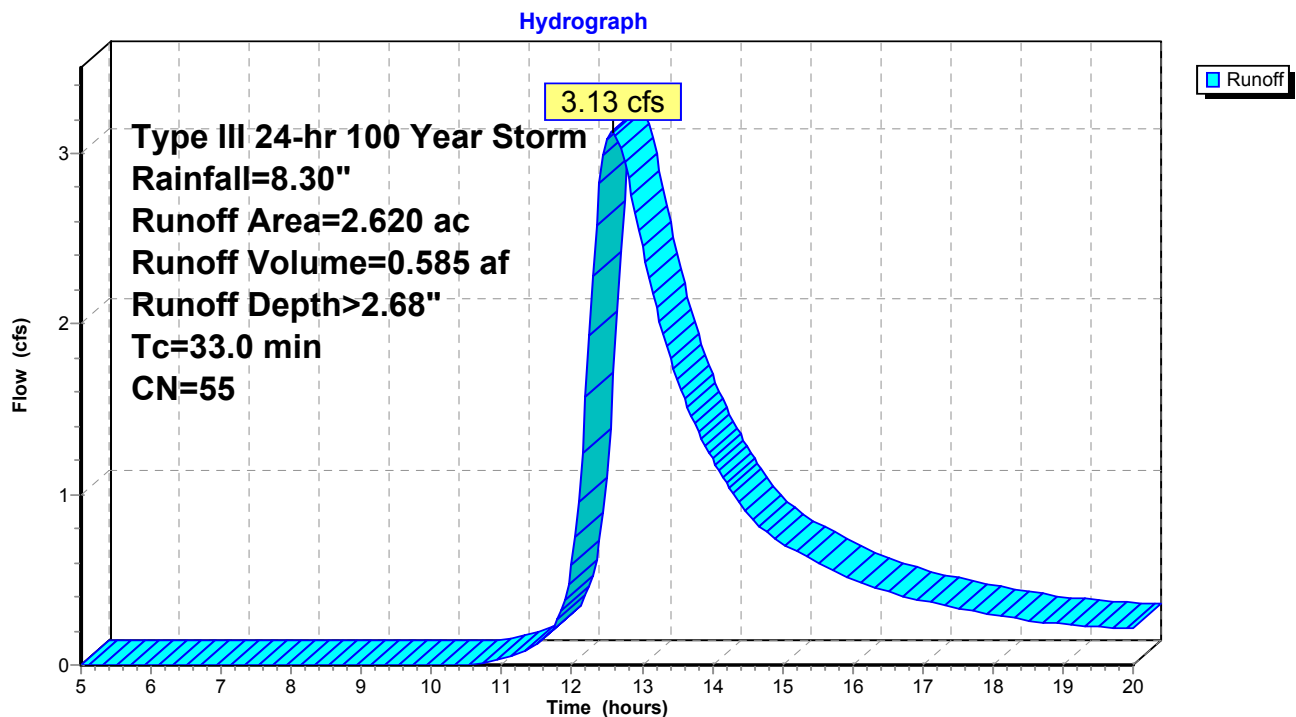
Runoff = 3.13 cfs @ 12.58 hrs, Volume= 0.585 af, Depth> 2.68"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 2.620	55	Woods
2.620		100.00% Pervious Area

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

### Subcatchment 1S: Woods



## Hamilton Estates Land Cover Comparison

Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 2S: Small Grain

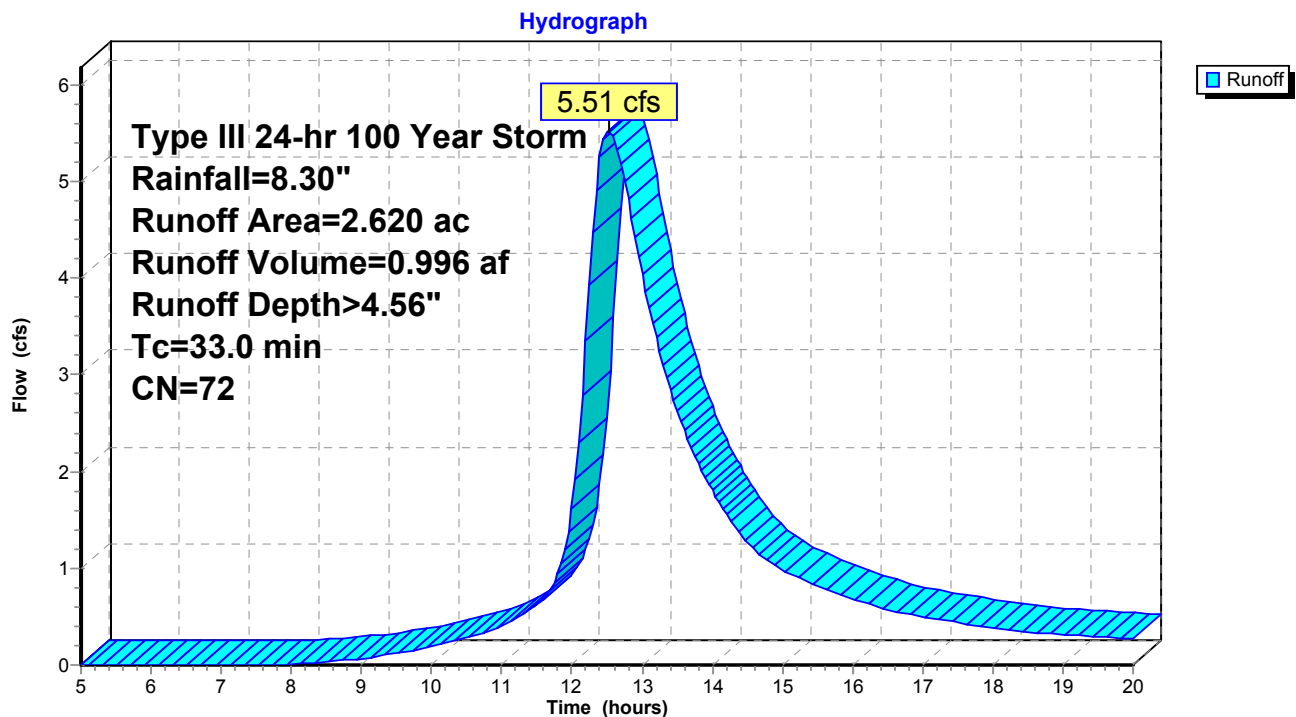
Runoff = 5.51 cfs @ 12.53 hrs, Volume= 0.996 af, Depth> 4.56"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 2.620	72	Small Grain
2.620		100.00% Pervious Area

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

### Subcatchment 2S: Small Grain





## Hamilton Estates Land Cover Comparison

Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 3S: Meadow

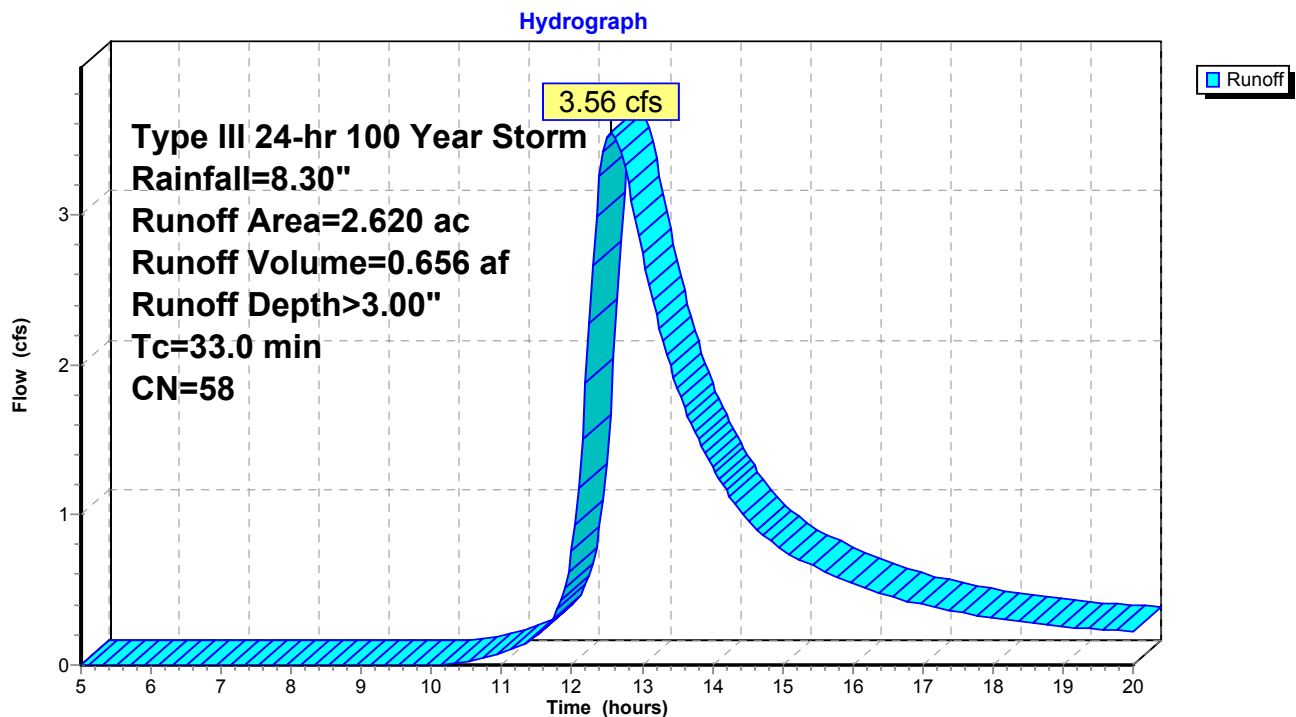
Runoff = 3.56 cfs @ 12.57 hrs, Volume= 0.656 af, Depth> 3.00"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 2.620	58	Meadow
2.620		100.00% Pervious Area

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

### Subcatchment 3S: Meadow



## Hamilton Estates Land Cover Comparison

Type III 24-hr 100 Year Storm Rainfall=8.30"

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### Summary for Subcatchment 4S: Brush

Runoff = 2.14 cfs @ 12.61 hrs, Volume= 0.427 af, Depth> 1.95"

Runoff by SCS TR-20 method, UH=Delmarva, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100 Year Storm Rainfall=8.30"

Area (ac)	CN	Description
* 2.620	48	Brush
2.620		100.00% Pervious Area

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

### Subcatchment 4S: Brush

