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Stormwater Report and Calculations

Louis Farm Village,
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Dracut, MA 01826

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Stormwater Chapter Index sheet

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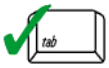
Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

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

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

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

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

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

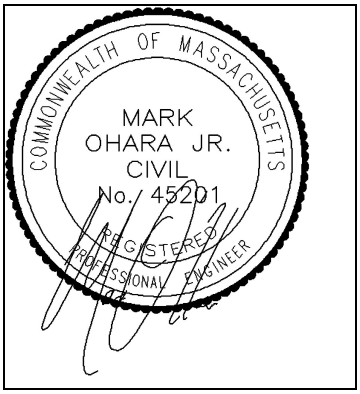
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



Mark O'Hara, PE 4-14-22
Signature and Date

Checklist

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

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

☒ No disturbance to any Wetland Resource Areas

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

☐ Reduced Impervious Area (Redevelopment Only)

☒ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

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

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

☒ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☒ Other (describe): Forebay

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

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

☒ Site is comprised solely of C and D soils and/or bedrock at the land surface

☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000

☐ Solid Waste Landfill pursuant to 310 CMR 19.000

☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☐ An Illicit Discharge Compliance Statement is attached;

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

Stormwater Management Compliance calculations:

- Standard 1 - Computations to show that discharge does not cause scour or erosion. In full compliance

Flared End Sections:

Rip Rap protection sized using the Fletcher and Grace equation from HEC-14 of the Federal Highway Administration is recommended for circular culverts:

$D_{50} = 0.2 \cdot D(Q/(\sqrt{g} \cdot D2.5))4/3(D/TW)$

D_{50} = mean rip rap stone diameter (in inches)
D = Diameter of Culvert (in feet)
Q = maximum flow rate, 25 year storm (in cfs)
g = 32.2ft/sec^2
TW = tail water height (feet)

FES 1	FES 2	FES 3
D = 1’	D = 1’	D = 1.25’
Q = 1.02 cfs	Q = 2.40 cfs	Q = 2.40 cfs
TW = 0.4’	TW = 0.4’	TW = 0.4’
D50 = 0.05’ (use 3” stone)	D50 = 0.16’ (use 3” stone)	D50 = 017’ (use 3” stone)

Flared End	**Avg. rock diameter**	**Apron width**	**Apron length**
FES 1, 2,3	3"	5 ft.	5 ft.

Detention Basin/Rain Garden #1:

Use 3” mean stone for FES, forebay, and overflow swale

Detention Basin/Rain Garden #2:

Use 3” mean stone for FES 2, forebay, and FES 3.

- Standard 2 - Peak Rate Attenuation:
  In full compliance - Refer to Drainage Calculations Summary showing reduction for all storm events.

- Standard 3 - Recharge
  - Soil Evaluation:

Soil testing has been performed onsite and were found to consist of loamy sands, and loamy fine sands as identified on NRCS map, specifically as Hinckley loamy sand and Wareham loamy fine sand These soils are classified as Hydrologic Soils Group A.

Required Recharge Volume –Use following table to determine volume:

NRCS HYDROLOGIC SOIL TYPE	APPROX. SOIL TEXTURE	TARGET DEPTH FACTOR (F)
A	sand	**0.6-inch**
B	loam	**0.35-inch**
C	silty loam	**0.25-inch**
D	clay	**0.1-inch**

Table 2.3.2: Recharge Target Depth by Hydrologic Soil Group

Recharge Required:

Required recharge determined by net increase in impervious surfaces.

Soil Type	New Impervious Area	Target Depth Factor	Recharge Volume
A	68,390 sf	0.60 in/sf	0 cf
B	0 sf	0.35 in/sf	0 cf
C	0 sf	0.25 in/sf	0 cf
D	0 sf	0.10 in/sf	0 cf
		Required Recharge Volume:	3420 cf

Recharge provided:

20 homes at 40 l.f. linear feet of roof drip trench per home at 4.0'w x 3.0'd and containing stone with void ratio of 0.40.
Provided Recharge Volume = 20 x 40' x (4.0'x2.0'x 0.40) = 3840 c.f.

- Sizing – Static Method used
- 72-hour Drawdown Analysis – See Rawls Table below:

Texture Class	NRCS Hydrologic Soil Group (HSG)	Infiltration Rate Inches/Hour
Sand	A	8.27
Loamy Sand	A	2.41
Sandy Loam	B	1.02
Loam	B	0.52
Silt Loam	C	0.27
Sandy Clay Loam	C	0.17
Clay Loam	D	0.09
Silty Clay Loam	D	0.06
Sandy Clay	D	0.05
Silty Clay	D	0.04
Clay	D	0.02

[1] *Table 2.3.3: Rawls, Brakensiek and Saxton, 1982*[1]
Computed time to Drawdown:

HSG soil group "A" = 2.41"/hr
Depth of trench = 24"
Void ratio: 0.40
Infiltration Rate: 2.41"/hr
Time to drawdown = (0.40x36")/2.41"/hr = 6.0 hours

- Standard 4 - Required Water Quality Volume.
  Determine WATER QUALITY TREATMENT VOLUME

  V_{WQ} = (D_{WQ}/12 inches/foot) * (A_{IMP} * 43,560 sq. ft./acre)
  V_{WQ} = (0.50"/12 inches/foot) * (1.57* 43,560 sq. ft./acre)= 2850 c.f.

  Water Quality Provided:

  Infiltration trenches = 3840 c.f. infiltration trench (see calculations above)

- Standard 5: Computations used to demonstrate compliance with Land Uses With Higher Potential Pollutant Loads (LUHPPLs):
  *N/A

- Standard 6: Computations used to determine compliance with stormwater discharging to Critical Areas:
  N/A

- Standard 7: Computations demonstrating that peak rate attenuation, recharge, and water quality treatment is provided to maximum extent practicable.
  N/A

- Standard 8: Computations related to sizing of erosion and sediment controls.
  Refer to Stormwater Management Report.

- Standard 9. Operations and Maintenance Plan/Manual
  Refer to Operations and Maintenance Manual in Stormwater Management Report

- Standard 10. Illicit Discharges to Drainage System
  No Illicit Discharge Statement to be signed by contractor,
  Stencil to be placed on each catch basin grate. See detail on detail sheet in plan set.

INSTRUCTIONS:

Version 1, Automated: Mar. 4, 2008

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

Location: Drainage Area 1 (site entrance)

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**0.25**	**1.00**	**0.25**	**0.75**
Sediment Forebay	**0.25**	**0.75**	**0.19**	**0.56**
Rain Garden	**0.90**	**0.56**	**0.51**	**0.06**
	0.00	**0.06**	**0.00**	**0.06**
	0.00	**0.06**	**0.00**	**0.06**

Total TSS Removal = **94%**

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

Project: **Louis Farm**

Prepared By: **Mark O'Hara**

*Equals remaining load from previous BMP (E)

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

INSTRUCTIONS:

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

Version 1, Automated: Mar. 4, 2008

Location: Drainage Area 2 (from drainage system)

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	0.25	1.00	0.25	0.75
Sediment Forebay	0.25	0.75	0.19	0.56
Rain Garden	0.90	0.56	0.51	0.06
	0.00	0.06	0.00	0.06
	0.00	0.06	0.00	0.06

Total TSS Removal = 94%

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

Project: Louis Farm

Prepared By: Mark O'Hara

*Equals remaining load from previous BMP (E)

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

INSTRUCTIONS:

Version 1, Automated: Mar. 4, 2008

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

Location: Drainage Area 2 (from sheet flow)

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	0.25	1.00	0.25	0.75
Vegetated Filter Strip >25 feet	0.10	0.75	0.08	0.68
Rain Garden	0.90	0.68	0.61	0.07
	0.00	0.07	0.00	0.07
	0.00	0.07	0.00	0.07

Total TSS Removal = 93%

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

Project: Louis Farm

Prepared By: Mark O'Hara

*Equals remaining load from previous BMP (E)

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

Summary:

The stormwater system designed for the Louis Farm residential development is designed to be in compliance with the Massachusetts Wetlands protection Act, the Dracut Wetlands Bylaw, and the Dracut Stormwater Management Program.

The stormwater system consists of two separate stormwater treatment areas. One small system will be located near the site entrance. The second, main system will be located near the center of the site. The entrance system will consist of deep sump hooded catch basins located at the intersection of the proposed road and Phineas Street. Stormwater will be directed to a forebay that will discharge into a rain garden/retention basin. The rain garden design serves two primary purposes to reduce suspended solids (>90%) and reduce stormwater runoff below existing, pre-development conditions. A second stormwater treatment area will be centrally located on the site. Similar to the other treatment area, it too will also consist of deep sump hooded catch basins located along the proposed road and will discharge into a forebay before entering a rain garden/detention basin. Some of the stormwater will enter the rain garden as sheet flow as this portion of the site will utilize low impact techniques such as reduced pavement width and country style drainage and no roadway curbing.

Soil test pits performed onsite confirm the soil designations from the Natural Resources Conservation Service (NRCS) soil report attached. The soils are very porous in nature, having a designation of Hydrologic Soils Group A. These design measures will reduce the potential for offsite flooding.

Existing Conditions:

The subject site is located on the east side of Phineas directly across the street from Goodhue Avenue. The parcel consists of 20.7 acres of land. Approximately 1/2 of the site was previously farmed. However, approximately 20 years ago, the land has been left to grow into a natural state. For the most part, the low grasses have been replaced by trees, but the trees have not reached maturity and some underlying brush exists in many areas. The front portion of the site up until a couple years ago contained a home and some impervious surfaces. The remaining ½ of the site consists of low lying wetlands that abut Beaver Brook. NRCS soil mapping show the majority of the soils consist of Hinckley loamy coarse sand in the higher elevations, and Wareham and Rippowam fine loamy sands, fine sands in the lower elevations. These soils are classified as "Hydrologic Soil Group A (Hinckley LCS) and Group A/D for the remainder. Group A/D soils are classified as Group A where there is separation from the water table, and group D where the soil is saturated (wetlands). For the purpose of this study, areas delineated as uplands are categorized as Hydrologic Soils Group A, and wetlands as Hydrologic Soils Group D.

The site consists of an ablation drumlin. Surface runoff generated onsite discharges to the perimeter (i.e. wetlands abutting Beaver Brook). The exception being a very small portion of the site identified as sub-catchment Area 1 that drains to Phineas Street, where it enters the existing stormwater system that discharges into Beaver Brook approximately 400’ to the south.

The following existing conditions maximum runoff rates have been computed and are summarized for the given storm events as follows:

Watershed	Area (Ac)	CN (ave)	Tc (min)	2Yr (cfs)	10Yr (cfs)	25Yr (cfs)	100 Yr (cfs)
Area 1	**0.95**	**48**	**6.6**	**0.01**	**0.34**	**0.89**	**1.92**
Area 2	**19.90**	**59**	**13.4**	**3.48**	**19.39**	**32.15**	**54.65**
Total	**20.85**			**3.48**	**19.66**	**32.98**	**55.97**

Proposed Conditions:

Proposed development will consist of the construction of one 22' wide paved road with an oversized cul-de-sac style road approximately 700' in length when measured to the center. The road will serve 20 proposed units (10 duplexes). Runoff from street will be directed to the subsurface street drainage system that will consist of deep sump hooded catch basins that discharge into forebays which then discharge into the constructed wetlands. Runoff from the cul-de-sac area will sheet flow into the large central rain garden. This detained runoff will mitigate discharge rates from the site. The remaining un-developed portion of the site that does not flow into the stormwater management system will continue to leave the site undetained. The combined effect of these stormwater mitigation measures will reduce the combined overall stormwater discharge rates.

It should be noted that the rain garden at the entranceway has been sized to retain all stormwater from all storm events up to and including the 100 year storm event. The totals tabulated below reflect this.

Watershed	Area (Ac)	CN (ave)	Tc (min)	2Yr (cfs)	10Yr (cfs)	25Yr (cfs)	100 Yr (cfs)
Area 1	**0.85**	**49**	**6.6**	**0.00**	**0.00**	**0.00**	**0.00**
Area 2 (detained)	**2.41**	**70**	**7.8**	**0.00**	**0.00**	**0.30**	**0.96**
Area 2 (un-detained)	**17.59**	**60**	**17.6**	**3.20**	**16.24**	**26.52**	**44.45**
Total	**20.85**			**3.30**	**16.24**	**26.55**	**45.23**

Watershed	2Yr	10Yr	25Yr	100 Yr
Change	**-5.2%**	**-17.4%**	**-19.6%**	**-19.2%**

The net effect is an overall **decrease** in peak runoff rates of approximately 11.0%.

Design Criteria and Methods:

The overall site drainage computations have been prepared in accordance with the *Urban Drainage Design Manual, Hydraulic Engineering Circular 22, Second Edition*, prepared in August 2001.

Additionally, HydrocadCAD©, a computer version of HEC-22, was used to calculate drainage basin characteristics. These include: Runoff Curve Numbers, Times of Concentration, and estimated Runoff Rates.

StormCAD uses the Unit Hydrograph Method for calculating runoff hydrographs. More specifically, it uses the triangular D-hour Unit Hydrograph approach. The peak discharge for the unit graph is computed using the following equation.

$$Qp = \frac{484AQ}{Tp}$$

Where:

Qp = peak outflow (cfs)
A = area (sq. miles)
Q = total excess precipitation (1 inch)
Tp = time to peak (hrs)

The time to peak, Tp and the time base, Tb are what determines the characteristics of the unit Hydrograph. Hydraflow computes these values using the following relationships.

$$Tp = \frac{Tc+D}{1.7}$$

Where:

Tp = time to peak (hrs)
Tc = time of concentration (hrs)
D = unit duration or time interval (hrs)
Tc = Time of Concentration.

The Time of Concentration (Tc) was computed by adding the travel times of sheet flow, shallow concentrated flow and open channel flow from each of the components A, B and C, as described in Technical Release 55 (TR-55) *Urban Hydrology for Small Watersheds*.

The site was initially analyzed for the peak stormwater flows during the 2,10, 25, and 100-year storm events. Each of the storm events were of a 24-hour duration and a Type III rainfall distribution. Existing site conditions were determined through onsite inspections, aerial photography, town topography maps and NRCS soil maps. The site was then analyzed under post-development conditions whereas the peak flows were used to compare the effects of the proposed development on the site and surrounding environment. The stormwater mitigation measures (detention basins, rain gardens, etc…)

were then designed using the calculated post development hydrographs.

The outlet structure flow rates were determined using standard orifice and/or weir flow equations and the basin inflow hydrographs as calculated by the computer model.

The roadway storm drainage system was designed using the Rational Method of determining peak flows from small watersheds. The formula utilized is as follows:

$$Q = ciA^*$$

Where:

Q = Peak Flow in cubic feet per second
c = Watershed Runoff Coefficient
i = Rainfall intensity in inches
A = Watershed area in acres.

*A twenty-five (25) year storm event was used for culvert sizing. Culvert sizing from 25 year storm using Rational Method generally produces higher runoff rates than 100 year HEC-22 maximum volume rates as the Rational Method simulates a short duration heavy thunderstorm and Type II event from HEC-22 is modelled from a 24 hr duration hurricane type storm event. Regardless, should catch basins surcharge, stormwater will overflow into adjacent detention basin/rain garden controls where it will be detained.

Soil Map—Middlesex County, Massachusetts
(133 Phineas Street)

Map Scale: 1:2,240 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 30 60 120 180

Feet
0 100 200 400 600

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

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

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

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

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

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

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

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

Soil Survey Area: Middlesex County, Massachusetts
Survey Area Data: Version 20, Jun 9, 2020

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

Date(s) aerial images were photographed: Oct 4, 2020—Oct 19, 2020

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	1.7	7.0%
4A	Rippowam fine sandy loam, 0 to 3 percent slopes	5.0	20.5%
32B	Wareham loamy fine sand, 0 to 5 percent slopes	5.8	23.8%
253B	Hinckley loamy sand, 3 to 8 percent slopes	9.7	39.5%
255B	Windsor loamy sand, 3 to 8 percent slopes	2.3	9.2%
Totals for Area of Interest		**24.5**	**100.0%**

POST-DEVELOPMENT

Catch Basin	Drainage Area	"C" Factor	Time of Concentration
	(Acres)		(Min.)
1	0.06	0.95	5.0
2	0.25	0.45	5.0
3	0.31	0.70	5.0
4	0.14	0.55	5.0
5	0.10	0.61	5.0
6	0.14	0.42	5.0

C Factor
(Rational Method)

Sub Area(s)	Surface Type	Area	"c"	cA	Weighted Average
	POST-DEVELOPMENT				
A1	**Impervious**	0.06	0.95	0.06	
	Grass	0.00	0.25	0.00	
	Woods	0.00	0.15	0.00	
	SUM:	0.06		0.06	0.95
				USE:	**0.95**
A2	**Impervious**	0.07	0.95	0.07	
	Grass	0.18	0.25	0.05	
	Woods	0.00	0.15	0.00	
	SUM:	0.25		0.12	0.45
				USE:	**0.45**
A3	**Impervious**	0.20	0.95	0.19	
	Grass	0.11	0.25	0.03	
	Woods	0.00	0.15	0.00	
	SUM:	0.31		0.22	0.70
				USE:	**0.70**

Sub Area	Surface Type	Area Ac.	"c"	cA	Weighted Average
	POST-DEVELOPMENT				
A4	**Impervious**	0.06	0.95	0.06	
	Grass	0.08	0.25	0.02	
	Woods	0.00	0.15	0.00	
	SUM:	0.14		0.08	0.55
				USE:	**0.55**
A5	**Impervious**	0.05	0.95	0.05	
	Grass	0.05	0.25	0.01	
	Woods	0.00	0.15	0.00	
	SUM:	0.10		0.06	0.61
				USE:	**0.61**
A6	**Impervious**	0.03	0.95	0.03	
	Grass	0.10	0.25	0.03	
	Woods	0.00	0.15	0.00	
	SUM:	0.14		0.06	0.42
				USE:	**0.42**

TIME OF CONCENTRATION

Louis Farm
Dracut, MA

Sub Area	Surface Type	Slope	Velocity	Length of Travel	Time of Travel "Tt"	Time of Concentration
		(%)	(ft/sec)	(ft)	(Sec.)	(Min.)
			POST-DEVELOPMENT			
A1	**Grass**	1.0%	1.00	5	5	0.1
	Asphalt	1.5%	2.40	175	73	1.2
				SUM=	78	1.3
					USE:	**5 Min.**
A2	**Grass**	2.0%	1.00	85	85	1.4
	Asphalt	1.5%	2.40	100	42	0.7
				SUM=	127	2.1
					USE:	**5 Min.**
A3	**Grass**	2.0%	1.00	40	40	0.7
	Asphalt	2.0%	2.80	250	89	1.5
				SUM=	129	2.2
					USE:	**5 Min.**
A4	**Grass**	2.0%	1.00	50	50	0.8
	Asphalt	1.5%	2.40	250	104	1.7
				SUM=	154	2.6
					USE:	**5 Min.**
A5	**Grass**	2.0%	1.00	45	45	0.8
	Asphalt	1.5%	2.40	320	133	2.2
				SUM=	178	3.0
					USE:	**5 Min.**
A6	**Grass**	2.0%	1.00	60	60	1.0
	Asphalt	1.5%	2.40	55	23	0.4
				SUM=	83	1.4
					USE:	**5 Min.**

Calculations for Runoff Determination for Small Areas

Job No. 191101

Project Location: LOUIS FARM, DRACUT, MA

Design Storm: 25 Year Frequency

Computed By: MO

Location (from)	Flow-line Elev. (out)	Location (to)	Flow-line Elev. (in)	A Acres	c	cA Acres	SUM cA Acres	Tc Min.	I In/Hr	Q Cfs	Dia of pipe Size	Mannings n	Q full Cfs	Slope Ft/Ft	V full Ft/sec	PIPE Length Ft	FLOW Time Min.
CB 1	101.00	DMH 1	100.90	0.06	0.95	0.057	0.057	5.0	6.00	0.34	12	0.012	3.52	0.0083	4.5	12	0.0
CB 2	101.00	DMH 1	100.90	0.25	0.45	0.113	0.113	5.0	6.00	0.68	12	0.012	3.52	0.0083	4.5	12	0.0
DMH 1	100.80	FES 1	100.70	--		--	0.170	5.0	6.00	1.02	12	0.012	2.88	0.0056	3.7	18	0.1
CB 3	97.00	DMH 2	96.70	0.31	0.70	0.217	0.217	5.0	6.00	1.30	12	0.012	4.98	0.0167	6.3	18	0.0
CB 4	97.00	DMH 2	96.70	0.14	0.55	0.077	0.077	5.0	6.00	0.46	12	0.012	4.73	0.0150	6.0	20	0.1
DMH 2	96.60	DMH 3	95.90	--	--	--	0.294	5.1	6.00	1.76	12	0.012	4.44	0.0132	5.6	53	0.0
DMH 3	95.80	DMH 4	95.24	--	--	--	0.294	5.1	6.00	1.76	12	0.012	3.97	0.0106	5.1	53	0.0
CB 5	95.40	DMH 3	95.24	0.10	0.61	0.061	0.061	5.0	6.00	0.37	12	0.012	5.46	0.0200	6.9	8	0.0
CB 6	95.40	DMH 3	95.24	0.14	0.42	0.059	0.059	5.0	6.00	0.35	12	0.012	4.28	0.0123	5.5	13	0.0
DMH 4	95.14	FES 2	94.90	--	--	--	0.414	5.0	5.80	2.40	12	0.012	2.73	0.0050	3.5	48	0.2

Rip Rap sizing - Louis Farm Village

Use equation: $D_{50} = 0.2 \cdot D(Q/(\sqrt{g} \cdot D2.5))4/3(D/TW)$

FES#1

Q	1.02	cfs	
D	1	'	
Tw	0.4	'	
g	32.2	ft/sec^2	
D_{50}=	0.05	'	Use 3" stone

FES#2

Q	2.40	cfs	
D	1	'	
Tw	0.4	'	
g	32.2	ft/sec^2	
D_{50}=	0.16	'	Use 3" stone

FES#3

Q	2.4	cfs	
D	1.25	'	
Tw	0.5	'	
g	32.2	ft/sec^2	
D_{50}=	0.17	'	Use 3" stone

Test pit results
Phineas Street
Dracut, MA
1-Nov-21
Sunny, mid 50's F

TP#1	Elev	103.38		
0-9"	Ap	loamy sand	10YR 3/2	
9-23"	Bw	loamy sand	10YR 5/6	
23-50"	C1	fine sand	10YR 7/2	
50-80"	C2	coarse sand	10YR 7/3	
	ESHW	66"	97.88	
	NO OBS, NO WEEP			

TP#2	Elev	99.35		
0-10"	Ap	sandy loam	10YR 3/3	
10-30"	Bw	sandy loam	10YR 5/6	15% boulders/stones
30-100"	C	fine sand	10YR 7/2	15% boulders/stones
	ESHW	>100"	below 91.01	
	NO OBS, NO WEEP			

TP#3	Elev	99.65		
0-10"	Ap	sandy loam	10YR 3/3	
10-24"	Bw	loamy sand	10YR 5/6	
24-55"	C1	fine sand	10YR 6/4	20% boulders
55-90"	C1	coarse sand	10YR 5/3	30% boulders 20% stones
	ESHW	>90"	below 92.15	
	NO OBS, NO WEEP			

TP#4	Elev	96.72		
0-10"	Ap	sandy loam	10YR 3/3	
10-24"	Bw	loamy sand	10YR 6/6	lenses sand
24-114"	C	fine sand	10YR 6/3	10% cobbles, 10% boulders
	ESHW	>90"	below 89.22'	
	NO OBS, NO WEEP			

TP#5	Elev	95.52		
0-12"	Ap	sandy loam	10YR 3/2	
12-28"	Bw	loamy sand	10YR 5/4	10% boulders
28-105"	C	fine sand	10YR 6/4	10% boulders
	ESHW	80"	88.85'	
	NO OBS, NO WEEP			

HSG	Mapunit Name	Mapunit Symbol
A	Gloucester gravelly fine sandy loam, 8 to 15 percent slopes, very stony	441C
A	Gloucester sandy loam, 15 to 25 percent slopes, extremely stony	442D
A	Gloucester sandy loam, 3 to 8 percent slopes	440B
A	Gloucester sandy loam, 3 to 8 percent slopes, extremely stony	442B
A	Gloucester sandy loam, 3 to 8 percent slopes, very stony	441B
A	Gloucester sandy loam, 8 to 15 percent slopes, extremely stony	442C
A	Gloucester sandy loam, 8 to 15 percent slopes, very stony	441C
A	Groton and Hinckley gravelly sandy loams, 25 to 35 percent slopes	298E
A	Groton gravelly sandy loam, 0 to 3 percent slopes	269A
A	Groton gravelly sandy loam, 15 to 25 percent slopes	269D
A	Groton gravelly sandy loam, 3 to 8 percent slopes	269B
A	Groton gravelly sandy loam, 8 to 15 percent slopes	269C
A	Haven silt loam, 0 to 3 percent slopes	251A
A	Haven silt loam, 3 to 8 percent slopes	251B
A	Haven-Urban land complex, 0 to 8 percent slopes	624B
A	Hinckley and Windsor soils, 25 to 35 percent slopes	257E
A	Hinckley and Windsor soils, steep	257E
A	Hinckley gravelly fine sandy loam, 0 to 3 percent slopes	242A
A	Hinckley gravelly fine sandy loam, 15 to 25 percent slopes	242D
A	Hinckley gravelly fine sandy loam, 3 to 8 percent slopes	242B
A	Hinckley gravelly fine sandy loam, 8 to 15 percent slopes	242C
A	Hinckley gravelly sandy loam, 0 to 3 percent slopes	242A
A	Hinckley gravelly sandy loam, 15 to 25 percent slopes	242D
A	Hinckley gravelly sandy loam, 15 to 35 percent slopes	242D
A	Hinckley gravelly sandy loam, 15 to 35 percent slopes, bouldery	289E
A	Hinckley gravelly sandy loam, 3 to 8 percent slopes	242B
A	Hinckley gravelly sandy loam, 3 to 8 percent slopes, bouldery	289B
A	Hinckley gravelly sandy loam, 8 to 15 percent slopes	242C
A	Hinckley gravelly sandy loam, 8 to 15 percent slopes, bouldery	289C
A	Hinckley loamy coarse sand, 0 to 3 percent slopes	253A
A	Hinckley loamy coarse sand, 15 to 35 percent slopes	253E
A	Hinckley loamy coarse sand, 3 to 8 percent slopes	253B
A	Hinckley loamy coarse sand, 8 to 15 percent slopes	253C
A	Hinckley loamy sand, 0 to 3 percent slopes	253A
A	Hinckley loamy sand, 15 to 35 percent slopes	253D
A	Hinckley loamy sand, 3 to 8 percent slopes	253B
A	Hinckley sandy loam, 0 to 3 percent slopes	245A
A	Hinckley sandy loam, 15 to 25 percent slopes	245D
A	Hinckley sandy loam, 15 to 35 percent slopes	245E
A	Hinckley sandy loam, 3 to 8 percent slopes	245B
A	Hinckley sandy loam, 3 to 8 percent slopes, very stony	290B
A	Hinckley sandy loam, 8 to 15 percent slopes, very stony	290C
A	Hinckley very gravelly sandy loam, 3 to 8 percent slopes	243B
A	Hinckley very gravelly sandy loam, 8 to 15 percent slopes	243C
A	Hinckley-Merrimac-Urban land complex, 3 to 15 percent slopes	745C
A	Hollis-Rock outcrop-Charlton complex, 15 to 25 percent slopes	104D

HSG	Mapunit Name	Mapunit Symbol
A/D	Freetown and Swansea mucks, coastal lowland, 0 to 1 percent slopes	52A, 54A
A/D	Freetown and Swansea soils, 0 to 1 percent slopes	54A
A/D	Freetown muck, 0 to 1 percent slopes	52, 52A
A/D	Freetown muck, 0 to 1 percent slopes, Connecticut Valley	52A
A/D	Freetown muck, ponded, 0 to 1 percent slopes	53, 53A
A/D	Freetown muck, ponded, 0 to 1 percent slopes, coastal lowland	53A
A/D	Greenwood and Chocorua mucks, 0 to 3 percent slopes	56A
A/D	Ipswich - Pawcatuck - Matunuck complex, 0 to 2 percent slopes, very frequent	66A
A/D	Ipswich mucky peat, 0 to 2 percent slopes, very frequently flooded	65
A/D	Ipswich-Pawcatuck-Matunuck complex, 0 to 1 percent slopes, freshened	666A
A/D	Klej and Pompton soils, 0 to 3 percent slopes	295A
A/D	Klej loamy coarse sand, sandy substratum, 0 to 5 percent slopes	297A
A/D	Leicester fine sandy loam, 0 to 3 percent slopes	67A
A/D	Leicester fine sandy loam, 3 to 8 percent slopes	67B
A/D	Limerick and Rumney soils, 0 to 3 percent slopes	713A
A/D	Lupton muck, 0 to 1 percent slopes	57A
A/D	Lyme gravelly loam, 0 to 5 percent slopes, extremely stony	83B
A/D	Massasoit - Mashpee complex, 0 to 3 percent slopes	37A
A/D	Maybid variant silty clay loam, 0 to 1 percent slopes	13A
A/D	Naumburg fine sandy loam, 0 to 5 percent slopes	29B
A/D	Ninigret fine sandy loam, 3 to 8 percent slopes	276B
A/D	Palms and Carlisle mucks, 0 to 1 percent slopes	58A
A/D	Pawcatuck and Matunuck mucky peats, 0 to 2 percent slopes, very frequently	64A
A/D	Pawcatuck mucky peat, 0 to 2 percent slopes, very frequently flooded	63A
A/D	Pipestone loamy coarse sand, 0 to 3 percent slopes	38A
A/D	Pipestone loamy fine sand, 0 to 3 percent slopes	38A
A/D	Pompton sandy loam, 0 to 3 percent slopes	408A
A/D	Rainberry coarse sand, 0 to 3 percent slope, sanded surface, inactive	701A
A/D	Rainberry coarse sand, 0 to 3 percent slopes	11A
A/D	Rainberry coarse sand, 0 to 3 percent slopes, sanded surface	7A
A/D	Ridgebury and Leicester fine sandy loams, 0 to 3 percent slopes, extremely stc	715A
A/D	Ridgebury and Leicester fine sandy loams, 3 to 8 percent slopes, extremely stc	715B
A/D	Rippowam fine sandy loam, 0 to 3 percent slopes	4A
A/D	Rippowam silt loam, 0 to 3 percent slopes	4
A/D	Rippowam very fine sandy loam, 0 to 3 percent slopes	4A
A/D	Rumney fine sandy loam, 0 to 3 percent slopes	18A
A/D	Scarboro and Walpole soils, 0 to 3 percent slopes	3A
A/D	Scarboro muck, coastal lowland, 0 to 3 percent slopes	6A
A/D	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	39A, 43A, 6A
A/D	Scarboro mucky sandy loam, 0 to 2 percent slopes	6A
A/D	Searsport loamy sand, 0 to 3 percent slopes	28A
A/D	Sheepscot fine sandy loam, 3 to 8 percent slopes	286B
A/D	Squamscott fine sandy loam, 0 to 3 percent slopes	200A
A/D	Swansea coarse sand, 0 to 3 percent slopes, sanded surface	60A
A/D	Tihonet coarse sand, 0 to 3 percent slopes	23A
A/D	Udipsamments, wet substratum, 0 to 3 percent slopes	700A

HSG	Mapunit Name	Mapunit Symbol
A/D	Walpole fine sandy loam, 3 to 8 percent slopes	31B
A/D	Walpole sandy loam, 0 to 3 percent slopes	31A
A/D	Wareham loamy fine sand, 0 to 3 percent slopes	32A
A/D	Wareham loamy fine sand, 0 to 5 percent slopes	32B
Hydrologic Group B/D		
B/D	Berryland Variant loamy sand, 0 to 3 percent slopes	25A
B/D	Birchwood sand, 0 to 3 percent slopes	320A
B/D	Birchwood sand, 0 to 3 percent slopes, very stony	321A
B/D	Birchwood sand, 3 to 8 percent slopes	320B
B/D	Birchwood sand, 3 to 8 percent slopes, very stony	321B
B/D	Birchwood sand, 8 to 15 percent slopes	320C
B/D	Birchwood sand, 8 to 15 percent slopes, very stony	321C
B/D	Birdsall mucky silt loam, 0 to 2 percent slopes	9A
B/D	Bucksport and Wonsqueak mucks, 0 to 3 percent slopes	59A
B/D	Endoaquents, 0 to 3 percent slopes, sanded surface	658A
B/D	Essex sandy loam, 15 to 25 percent slopes, very stony	386D
B/D	Essex sandy loam, 3 to 8 percent slopes, very stony	386B
B/D	Essex sandy loam, 8 to 15 percent slopes, very stony	386C
B/D	Fredon fine sandy loam, 0 to 3 percent slopes	34A
B/D	Freetown coarse sand, 0 to 3 percent slopes, sanded surface	55A
B/D	Freetown, Swansea coarse sands, 0 to 3 percent slopes, sanded surface and in	55A, 704A
B/D	Halsey fine sandy loam, 0 to 3 percent slopes	35A
B/D	Lim very fine sandy loam, 0 to 3 percent slopes	19A
B/D	Limerick silt loam, 0 to 2 percent slopes, frequently flooded	8A
B/D	Limerick silt loam, 0 to 3 percent slopes	8A
B/D	Lyons mucky silt loam, 0 to 3 percent slopes	85A
B/D	Metacomet fine sandy loam, 0 to 3 percent slopes	368A
B/D	Metacomet fine sandy loam, 3 to 8 percent slopes	368B
B/D	Metacomet fine sandy loam, 3 to 8 percent slopes, very stony	369B
B/D	Metacomet fine sandy loam, 8 to 15 percent slopes	368C
B/D	Metacomet fine sandy loam, 8 to 15 percent slopes, very stony	369C
B/D	Montauk fine sandy loam, 15 to 25 percent slopes, very stony	301D
B/D	Newport loam, 15 to 35 percent slopes	325E
B/D	Newport loam, 15 to 35 percent slopes, very stony	326E
B/D	Newport loam, 3 to 8 percent slopes, very stony	326B
B/D	Newport loam, 8 to 15 percent slopes	325C
B/D	Newport loam, 8 to 15 percent slopes, very stony	326C
B/D	Ninigret very fine sandy loam, 0 to 3 percent slopes	276A
B/D	Ninigret very fine sandy loam, 3 to 8 percent slopes	276B
B/D	Podunk fine sandy loam, 0 to 3 percent slopes, occasionally flooded	95A
B/D	Pootatuck very fine sandy loam, 0 to 3 percent slopes, occasionally flooded	2A
B/D	Raypol silt loam, 0 to 5 percent slopes	33B
B/D	Ridgebury fine sandy loam, 0 to 3 percent slopes	70A
B/D	Ridgebury fine sandy loam, 3 to 8 percent slopes	70B
B/D	Rumney fine sandy loam, 0 to 3 percent slopes, frequently flooded	18A
B/D	Saco mucky silt loam, 0 to 1 percent slopes	36A

Primary Reference:

ASCE, 1992 and Rossmiller, 1980

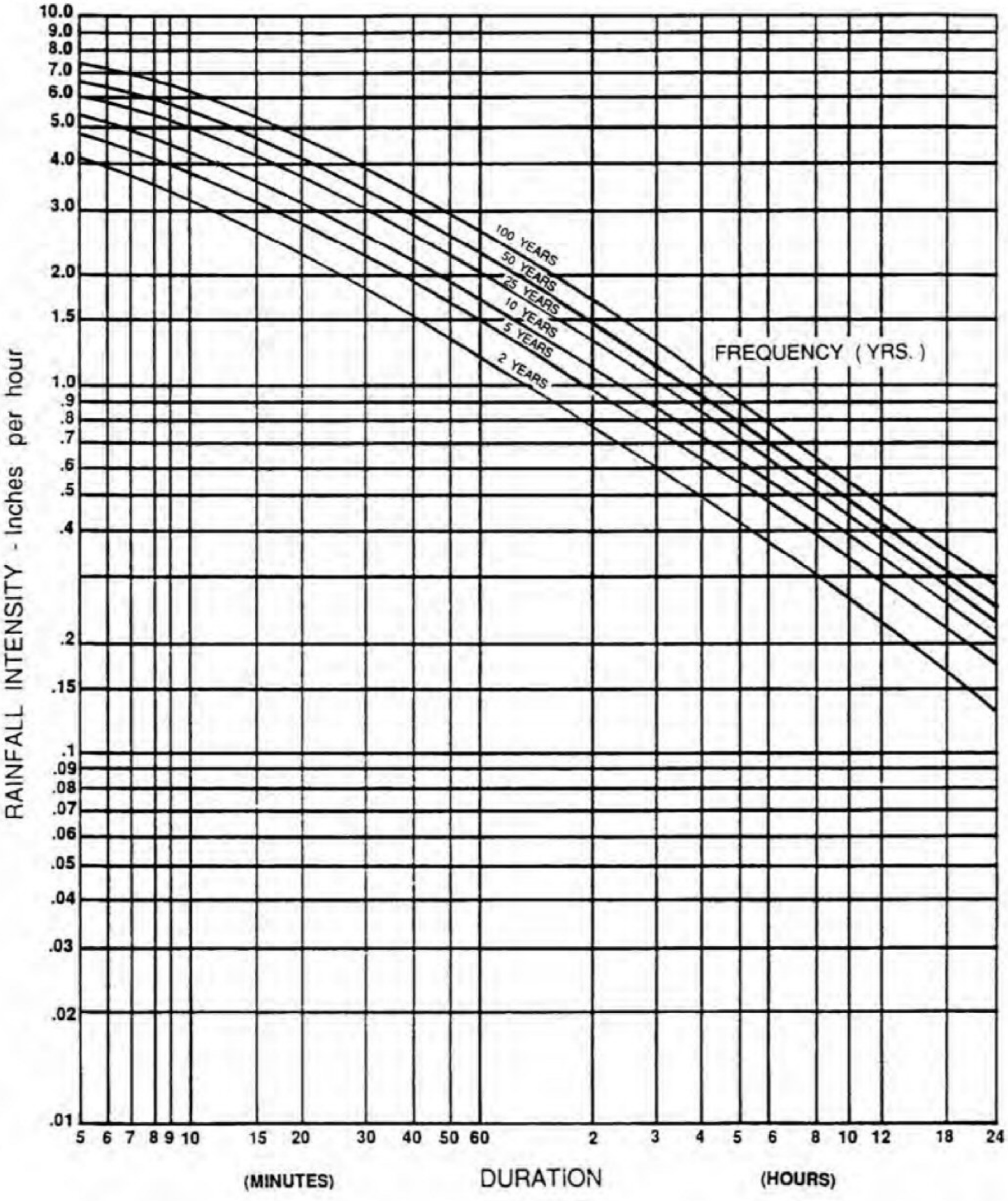
Runoff Coefficients for Rational Formula

Type of Drainage Area	Runoff Coefficient, C*
Business:	
Downtown areas	0.70 – 0.95
Neighborhood areas	0.50 – 0.70
Residential:	
Single-family areas	0.30 – 0.50
Multi-units, detached	0.40 – 0.60
Multi-units, attached	0.60 – 0.75
Suburban	0.25 – 0.40
Apartment dwelling areas	0.50 – 0.70
Industrial:	
Light areas	0.50 – 0.80
Heavy areas	0.60 – 0.90
Parks, cemeteries	0.10 – 0.25
Playgrounds	0.20 – 0.40
Railroad yard areas	0.20 – 0.40
Unimproved areas	0.10 – 0.30
Lawns:	
Sandy soil, flat, 2%	0.05 – 0.10
Sandy soil, average, 2 - 7%	0.10 – 0.15
Sandy soil, steep, 7%	0.15 – 0.20
Heavy soil, flat, 2%	0.13 – 0.17
Heavy soil, average 2 - 7%	0.18 – 0.22
Heavy soil, steep, 7%	0.25 – 0.35
Streets:	
Asphaltic	0.70 – 0.95
Concrete	0.80 – 0.95
Brick	0.70 – 0.85
Drives and walks	0.75 – 0.85
Roofs	0.75 – 0.95

* Higher values are usually appropriate for steeply sloped areas and longer return periods because infiltration and other losses have a proportionally smaller effect on runoff in these cases.

Exhibit 8-12

Intensity - Duration - Frequency Curve for Boston, MA



Source: TR55 - Urban Hydrology for Small Wetlands, NRCS

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

1 The n values are a composite of information compiled by Engman (1986).

2 Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

3 When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2/]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3/]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4/]	48	65	73
Woods—grass combination (orchard or tree farm). [5/]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6/]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4/]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 ***Poor:*** <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 ***Poor:*** <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 ***Poor:*** Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

NOAA Atlas 14, Volume 10, Version 3
Location name: Dracut, Massachusetts, USA*
Latitude: 42.6707°, Longitude: -71.3331°
Elevation: 116.76 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.317** (0.254-0.395)	**0.377** (0.302-0.469)	**0.475** (0.379-0.592)	**0.556** (0.440-0.697)	**0.667** (0.509-0.869)	**0.751** (0.560-0.997)	**0.838** (0.604-1.15)	**0.935** (0.636-1.31)	**1.07** (0.699-1.55)	**1.19** (0.751-1.75)
10-min	**0.450** (0.361-0.559)	**0.534** (0.428-0.665)	**0.672** (0.536-0.839)	**0.787** (0.624-0.987)	**0.945** (0.721-1.23)	**1.06** (0.793-1.41)	**1.19** (0.855-1.63)	**1.33** (0.901-1.86)	**1.52** (0.990-2.20)	**1.68** (1.06-2.48)
15-min	**0.529** (0.424-0.658)	**0.629** (0.503-0.782)	**0.792** (0.631-0.988)	**0.926** (0.734-1.16)	**1.11** (0.848-1.45)	**1.25** (0.933-1.66)	**1.40** (1.01-1.92)	**1.56** (1.06-2.19)	**1.79** (1.17-2.59)	**1.98** (1.25-2.91)
30-min	**0.727** (0.583-0.903)	**0.863** (0.691-1.07)	**1.09** (0.866-1.36)	**1.27** (1.01-1.60)	**1.53** (1.17-1.99)	**1.72** (1.28-2.28)	**1.92** (1.38-2.64)	**2.14** (1.46-3.00)	**2.46** (1.60-3.56)	**2.72** (1.72-4.00)
60-min	**0.925** (0.741-1.15)	**1.10** (0.879-1.37)	**1.38** (1.10-1.72)	**1.62** (1.28-2.03)	**1.94** (1.48-2.53)	**2.19** (1.63-2.91)	**2.44** (1.76-3.35)	**2.73** (1.85-3.82)	**3.13** (2.03-4.52)	**3.45** (2.18-5.08)
2-hr	**1.17** (0.941-1.44)	**1.41** (1.13-1.74)	**1.80** (1.45-2.23)	**2.13** (1.70-2.65)	**2.58** (1.99-3.36)	**2.91** (2.19-3.88)	**3.27** (2.40-4.53)	**3.71** (2.53-5.18)	**4.39** (2.86-6.31)	**4.96** (3.15-7.27)
3-hr	**1.34** (1.08-1.64)	**1.62** (1.31-2.00)	**2.09** (1.69-2.59)	**2.48** (1.99-3.08)	**3.02** (2.34-3.93)	**3.41** (2.59-4.54)	**3.85** (2.83-5.33)	**4.39** (2.99-6.10)	**5.24** (3.42-7.51)	**5.98** (3.80-8.72)
6-hr	**1.70** (1.39-2.08)	**2.07** (1.69-2.54)	**2.68** (2.18-3.30)	**3.19** (2.57-3.94)	**3.89** (3.03-5.04)	**4.40** (3.36-5.83)	**4.97** (3.69-6.86)	**5.68** (3.89-7.85)	**6.81** (4.46-9.71)	**7.80** (4.98-11.3)
12-hr	**2.14** (1.76-2.61)	**2.61** (2.15-3.18)	**3.38** (2.76-4.13)	**4.02** (3.26-4.93)	**4.89** (3.83-6.29)	**5.54** (4.24-7.28)	**6.25** (4.64-8.54)	**7.12** (4.90-9.78)	**8.48** (5.57-12.0)	**9.65** (6.18-13.9)
24-hr	**2.56** (2.12-3.09)	**3.14** (2.59-3.79)	**4.08** (3.36-4.95)	**4.87** (3.98-5.93)	**5.95** (4.68-7.59)	**6.74** (5.19-8.80)	**7.61** (5.68-10.3)	**8.68** (5.99-11.8)	**10.3** (6.81-14.5)	**11.8** (7.54-16.8)
2-day	**2.89** (2.40-3.47)	**3.58** (2.98-4.30)	**4.71** (3.91-5.68)	**5.65** (4.65-6.85)	**6.95** (5.51-8.82)	**7.90** (6.12-10.3)	**8.94** (6.72-12.1)	**10.2** (7.10-13.9)	**12.3** (8.13-17.2)	**14.1** (9.06-20.0)
3-day	**3.16** (2.64-3.78)	**3.90** (3.26-4.67)	**5.11** (4.25-6.14)	**6.11** (5.05-7.38)	**7.50** (5.97-9.49)	**8.51** (6.62-11.0)	**9.63** (7.26-13.0)	**11.0** (7.66-14.9)	**13.2** (8.75-18.4)	**15.1** (9.74-21.4)
4-day	**3.42** (2.87-4.08)	**4.18** (3.51-5.00)	**5.43** (4.54-6.51)	**6.47** (5.36-7.79)	**7.90** (6.30-9.96)	**8.95** (6.98-11.5)	**10.1** (7.62-13.6)	**11.5** (8.03-15.5)	**13.8** (9.14-19.1)	**15.7** (10.1-22.2)
7-day	**4.14** (3.50-4.92)	**4.94** (4.17-5.87)	**6.25** (5.25-7.45)	**7.34** (6.12-8.79)	**8.83** (7.08-11.1)	**9.94** (7.77-12.7)	**11.1** (8.41-14.8)	**12.6** (8.81-16.9)	**14.8** (9.88-20.5)	**16.7** (10.8-23.5)
10-day	**4.81** (4.08-5.69)	**5.64** (4.77-6.68)	**6.99** (5.89-8.30)	**8.11** (6.79-9.69)	**9.66** (7.76-12.0)	**10.8** (8.46-13.7)	**12.0** (9.08-15.9)	**13.5** (9.47-18.0)	**15.7** (10.5-21.6)	**17.5** (11.4-24.5)
20-day	**6.75** (5.76-7.93)	**7.66** (6.53-9.01)	**9.15** (7.76-10.8)	**10.4** (8.75-12.3)	**12.1** (9.74-14.8)	**13.4** (10.5-16.7)	**14.7** (11.0-19.0)	**16.1** (11.4-21.4)	**18.1** (12.2-24.8)	**19.7** (12.8-27.5)
30-day	**8.37** (7.17-9.79)	**9.34** (8.00-11.0)	**10.9** (9.33-12.9)	**12.3** (10.4-14.5)	**14.1** (11.4-17.2)	**15.5** (12.2-19.2)	**16.9** (12.7-21.6)	**18.3** (13.0-24.2)	**20.2** (13.6-27.5)	**21.6** (14.1-30.0)
45-day	**10.4** (8.95-12.1)	**11.5** (9.85-13.4)	**13.2** (11.3-15.5)	**14.6** (12.4-17.2)	**16.6** (13.5-20.1)	**18.2** (14.3-22.4)	**19.7** (14.7-24.9)	**21.1** (15.0-27.7)	**22.9** (15.5-31.0)	**24.1** (15.8-33.4)
60-day	**12.1** (10.5-14.1)	**13.3** (11.4-15.4)	**15.1** (13.0-17.6)	**16.6** (14.2-19.5)	**18.7** (15.2-22.6)	**20.4** (16.1-25.0)	**22.0** (16.5-27.6)	**23.4** (16.7-30.6)	**25.2** (17.1-34.0)	**26.4** (17.2-36.3)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

PDS-based depth-duration-frequency (DDF) curves
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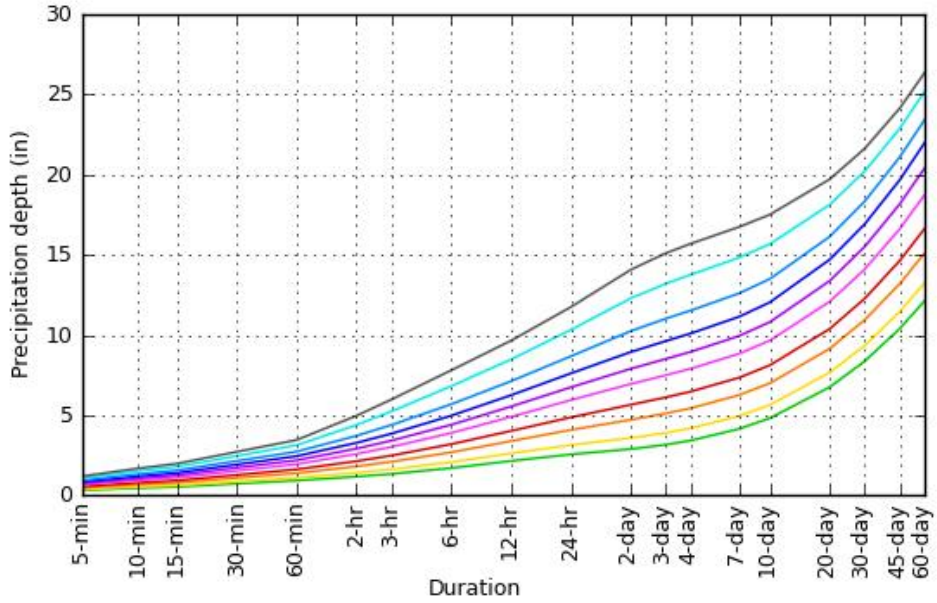

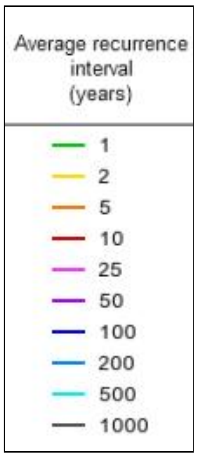

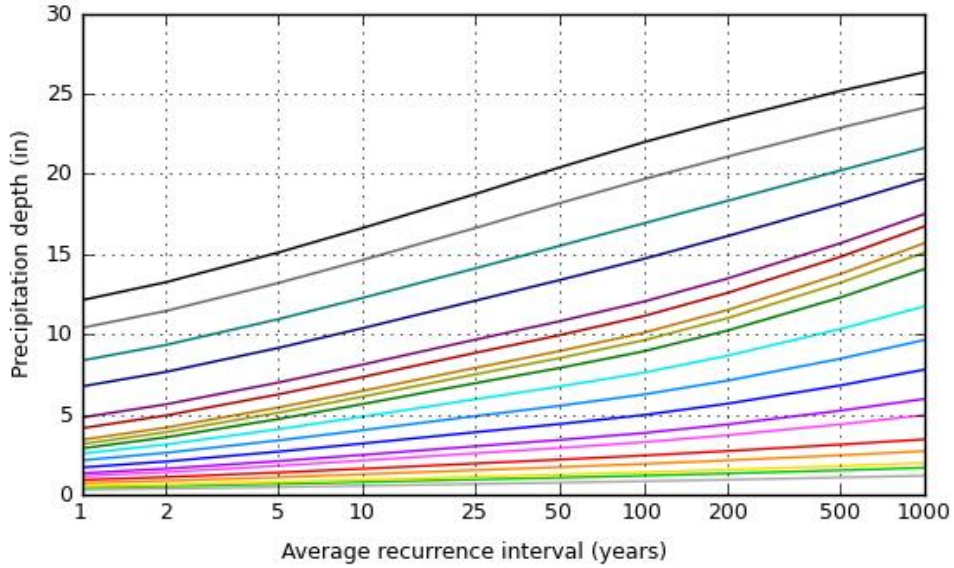

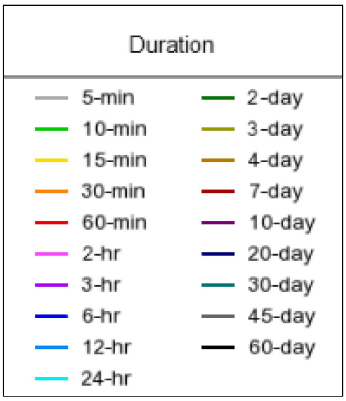

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Created (GMT): Wed Apr 13 16:58:43 2022

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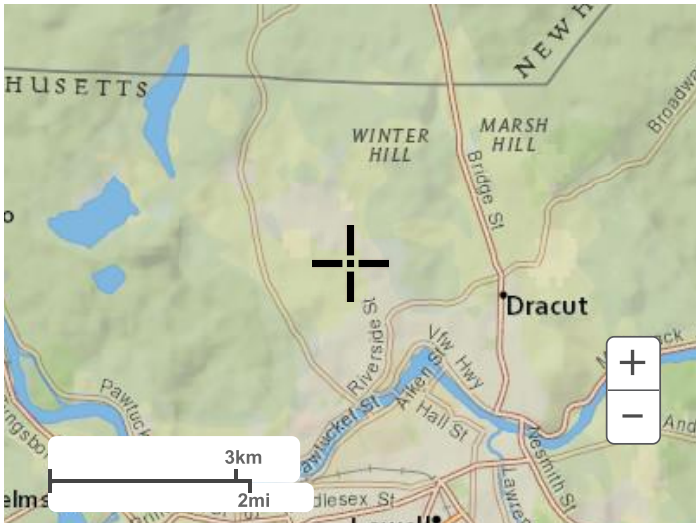
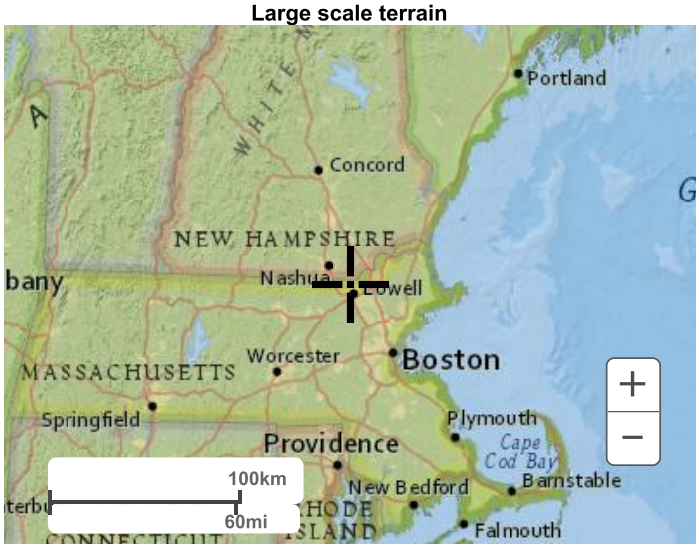
Maps & aerials

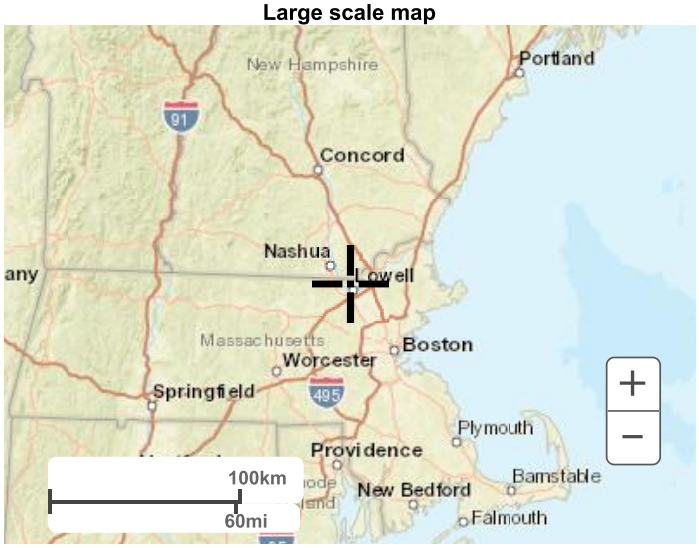
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

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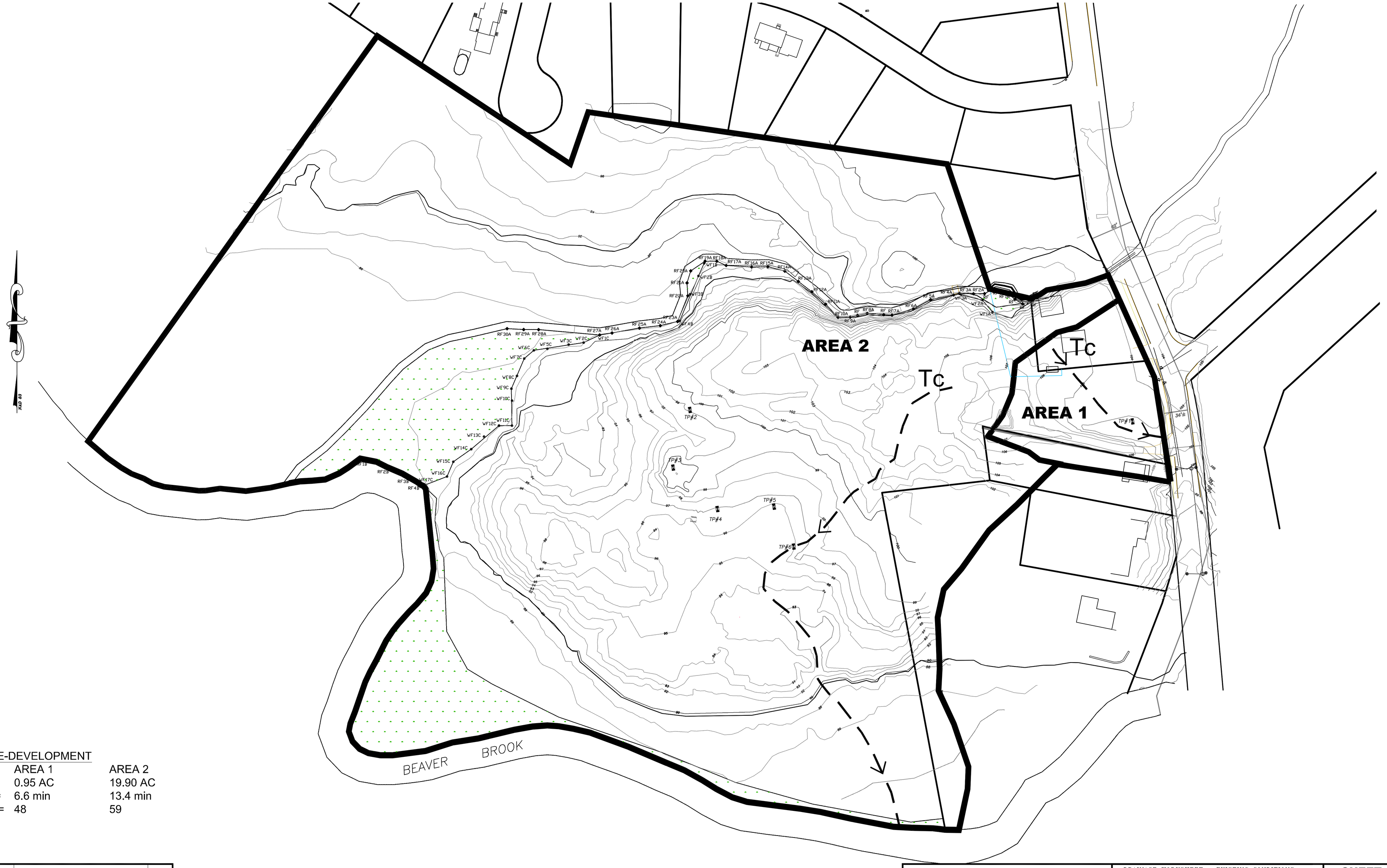
US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer



PRE-DEVELOPMENT

	AREA 1	AREA 2
A=	0.95 AC	19.90 AC
Tc=	6.6 min	13.4 min
CN=	48	59

REVISION	DATE	DESCRIPTION	BY

ENGINEER	DRAFTER	CHECKED	MAP CHECK	RECORDED

PREPARED FOR:
133 PHINEAS STREET LLC
2100 LAKEVIEW AVENUE, UNIT B
DRACUT, MA

SCALE: 1" = 60' APRIL 14, 2022

60 0 60 120 180
SCALE IN FEET

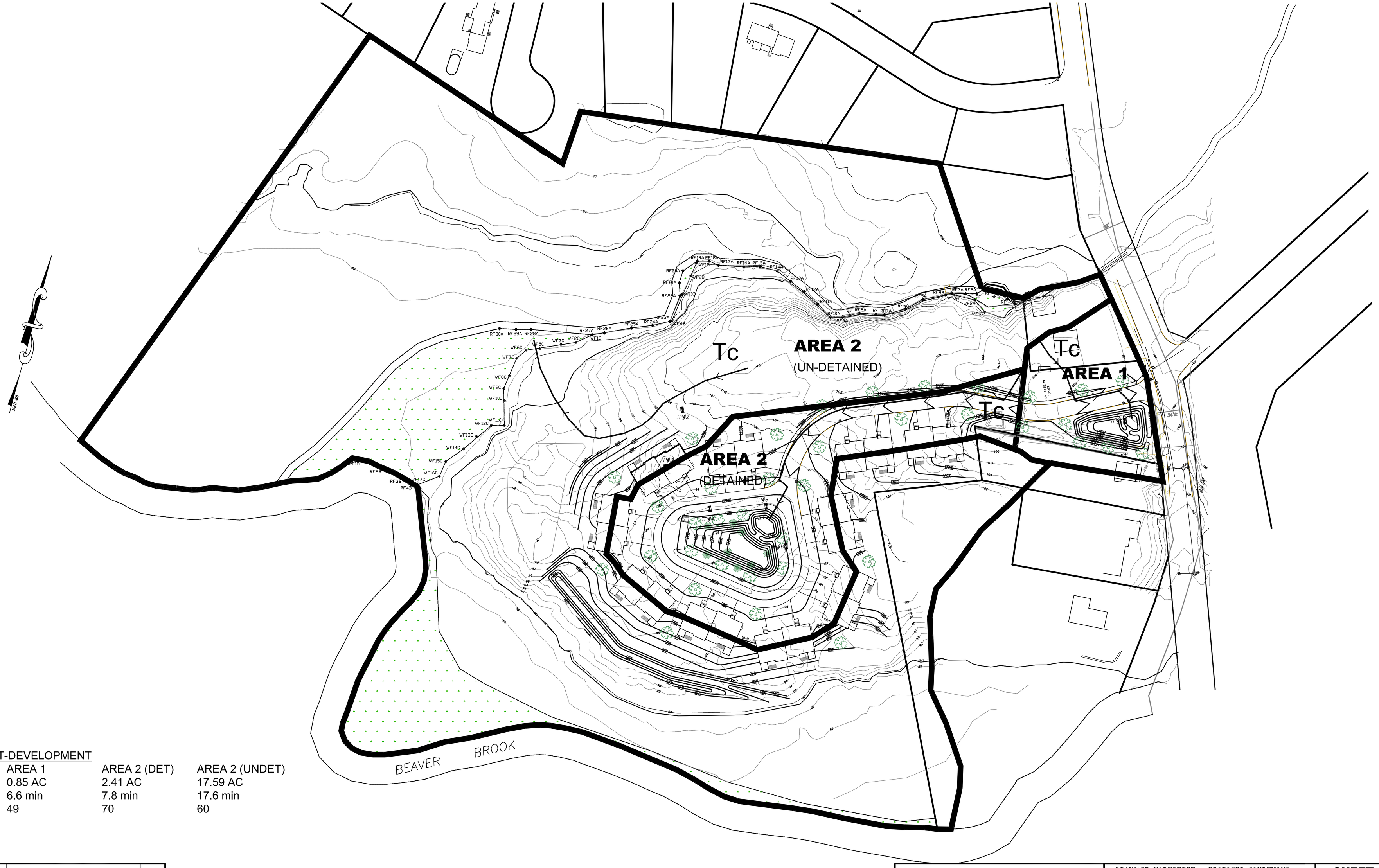
DRAINAGE WORKSHEET - EXISTING CONDITIONS
LOUIS FARM VILLAGE
133 PHINEAS STREET
DRACUT, MA

PREPARED BY:

O'Hara Engineering Services, LLC
21 MANSION DRIVE
LOWELL, MA 01852-2941
PHONE 617 312-4629
WWW.OHARAENGINEERING.COM

SHEET
1
OF 3

190101-DRAIN-DWG



POST-DEVELOPMENT

	AREA 1	AREA 2 (DET)	AREA 2 (UNDET)
A=	0.85 AC	2.41 AC	17.59 AC
Tc=	6.6 min	7.8 min	17.6 min
CN=	49	70	60

REVISION	DATE	DESCRIPTION	BY

ENGINEER	DRAFTER	CHECKED	MAP CHECK	RECORDED

PREPARED FOR:
133 PHINEAS STREET LLC
2100 LAKEVIEW AVENUE, UNIT B
DRACUT, MA

SCALE: 1" = 60' APRIL 14, 2022

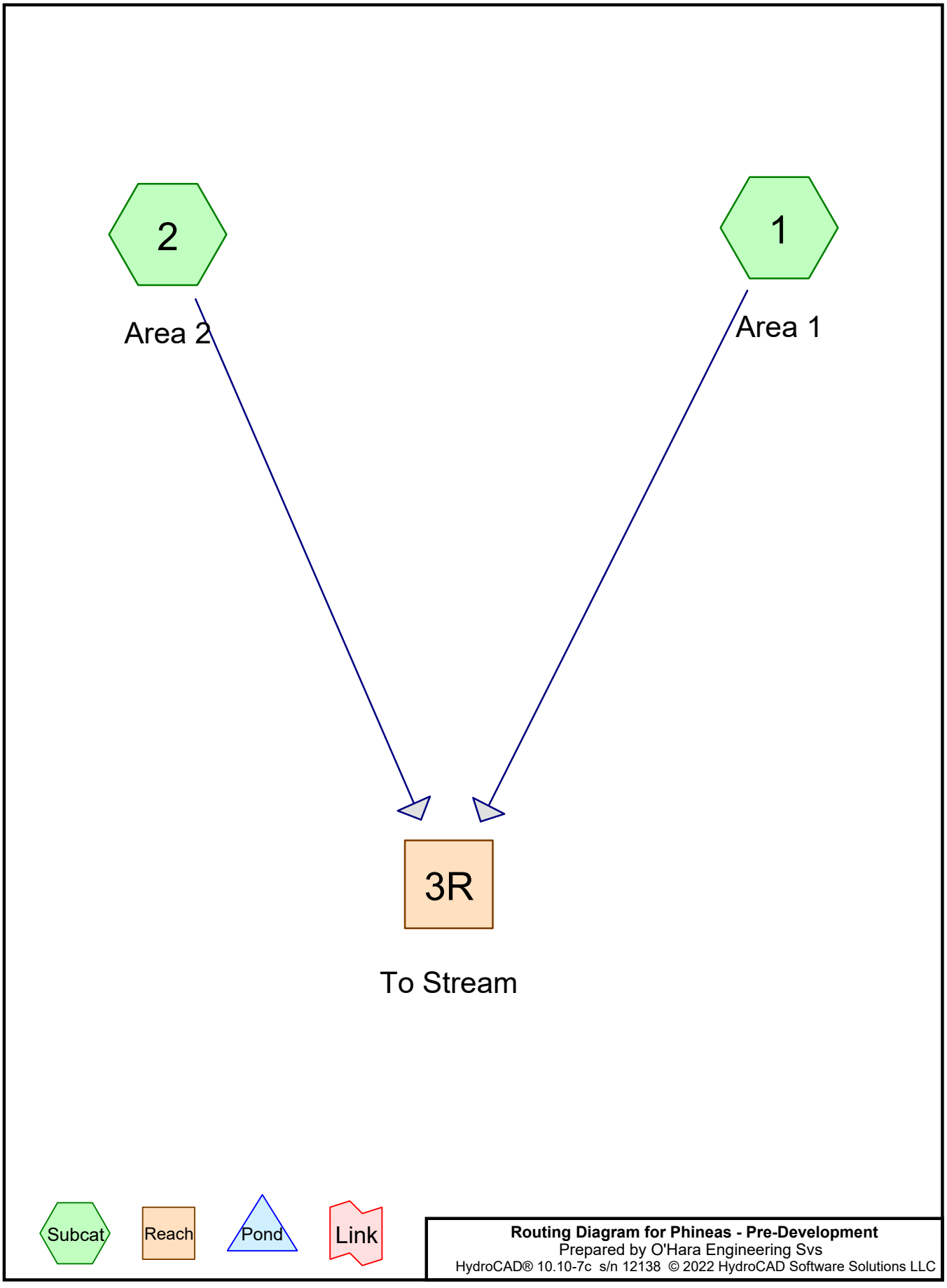
60 0 60 120 180
SCALE IN FEET

DRAINAGE WORKSHEET - PROPOSED CONDITIONS
LOUIS FARM VILLAGE
133 PHINEAS STREET
DRACUT, MA

PREPARED BY:
O'Hara Engineering Services, LLC
21 MANSION DRIVE
LOWELL, MA 01852-2941
PHONE 617 312-4629
WWW.OHARAENGINEERING.COM

SHEET
2
OF 3

190101-DRAIN-DWG



Routing Diagram for Phineas - Pre-Development
Prepared by O'Hara Engineering Svs

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	NRCC 24-hr	C	Default	24.00	1	3.14	2
2	10-Year	NRCC 24-hr	C	Default	24.00	1	4.87	2
3	25-Year	NRCC 24-hr	C	Default	24.00	1	5.95	2
4	100-Year	NRCC 24-hr	C	Default	24.00	1	7.61	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
7.710	36	(2)
3.430	79	(2)
0.140	98	Impervious Surfaces (1)
0.060	98	Impervious surfaces (2)
1.860	39	Open Space - Good cond - A soils (2)
0.690	39	Open Space - good - A soils (1)
0.110	36	Woods - fair - A soils (1)
14.000	**48**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
14.000	Other	1, 2
14.000		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	11.140	11.140		2
0.000	0.000	0.000	0.000	0.140	0.140	Impervious Surfaces	1
0.000	0.000	0.000	0.000	0.060	0.060	Impervious surfaces	2
0.000	0.000	0.000	0.000	1.860	1.860	Open Space - Good cond - A soils	2
0.000	0.000	0.000	0.000	0.690	0.690	Open Space - good - A soils	1
0.000	0.000	0.000	0.000	0.110	0.110	Woods - fair - A soils	1
0.000	**0.000**	**0.000**	**0.000**	**14.000**	**14.000**	**TOTAL AREA**	

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1: Area1 Runoff Area=0.940 ac 14.89% Impervious Runoff Depth=0.06"
Flow Length=225' Tc=9.2 min CN=47 Runoff=0.01 cfs 0.005 af

Subcatchment2: Area2 Runoff Area=13.060 ac 0.46% Impervious Runoff Depth=0.08"
Flow Length=825' Tc=14.7 min CN=48 Runoff=0.12 cfs 0.087 af

Reach3R: To Stream Inflow=0.13 cfs 0.092 af
Outflow=0.13 cfs 0.092 af

Total Runoff Area = 14.000 ac Runoff Volume = 0.092 af Average Runoff Depth = 0.08"
98.57% Pervious = 13.800 ac 1.43% Impervious = 0.200 ac

Summary for Subcatchment 1: Area 1

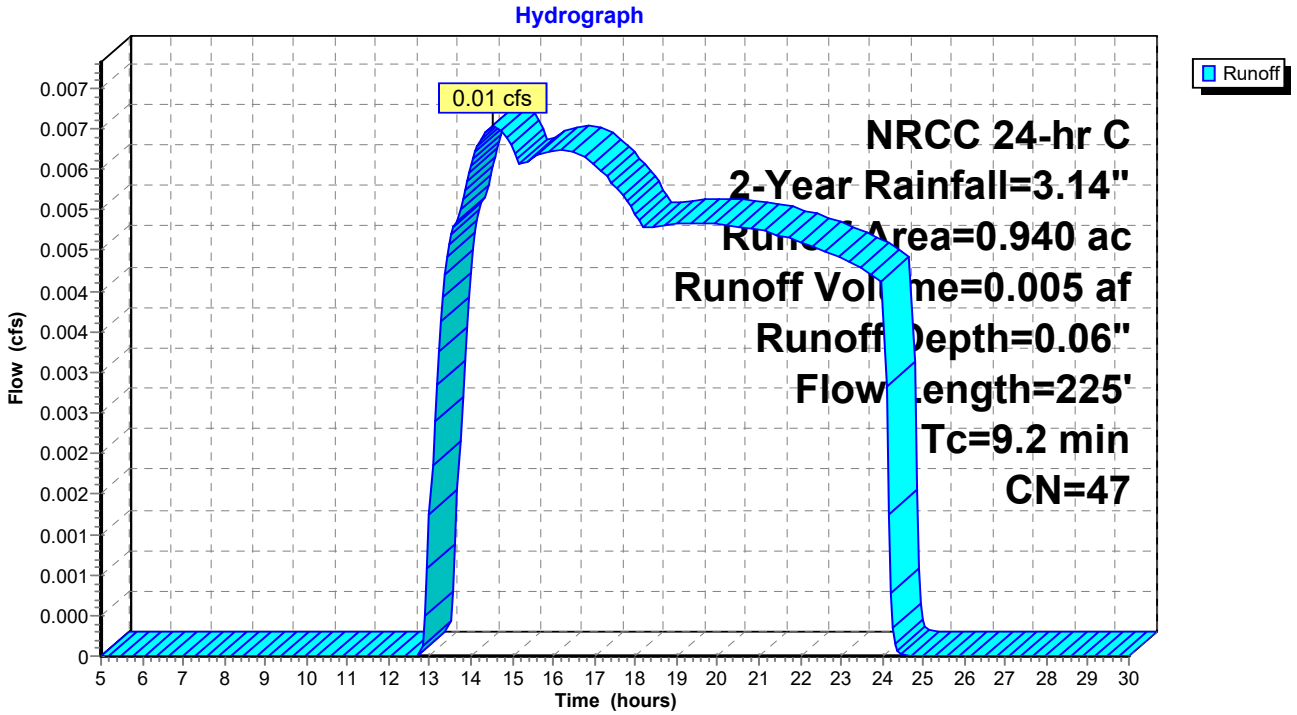
Runoff = 0.01 cfs @ 14.54 hrs, Volume= 0.005 af, Depth= 0.06"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 2-Year Rainfall=3.14"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.690	39	Open Space - good - A soils
*	0.110	36	Woods - fair - A soils
	0.940	47	Weighted Average
	0.800		85.11% Pervious Area
	0.140		14.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
2.9	175	0.0200	0.99		**Shallow Concentrated Flow, Shallow concentrated flow** Short Grass Pasture Kv= 7.0 fps
9.2	225	Total			

Subcatchment 1: Area 1



Summary for Subcatchment 2: Area 2

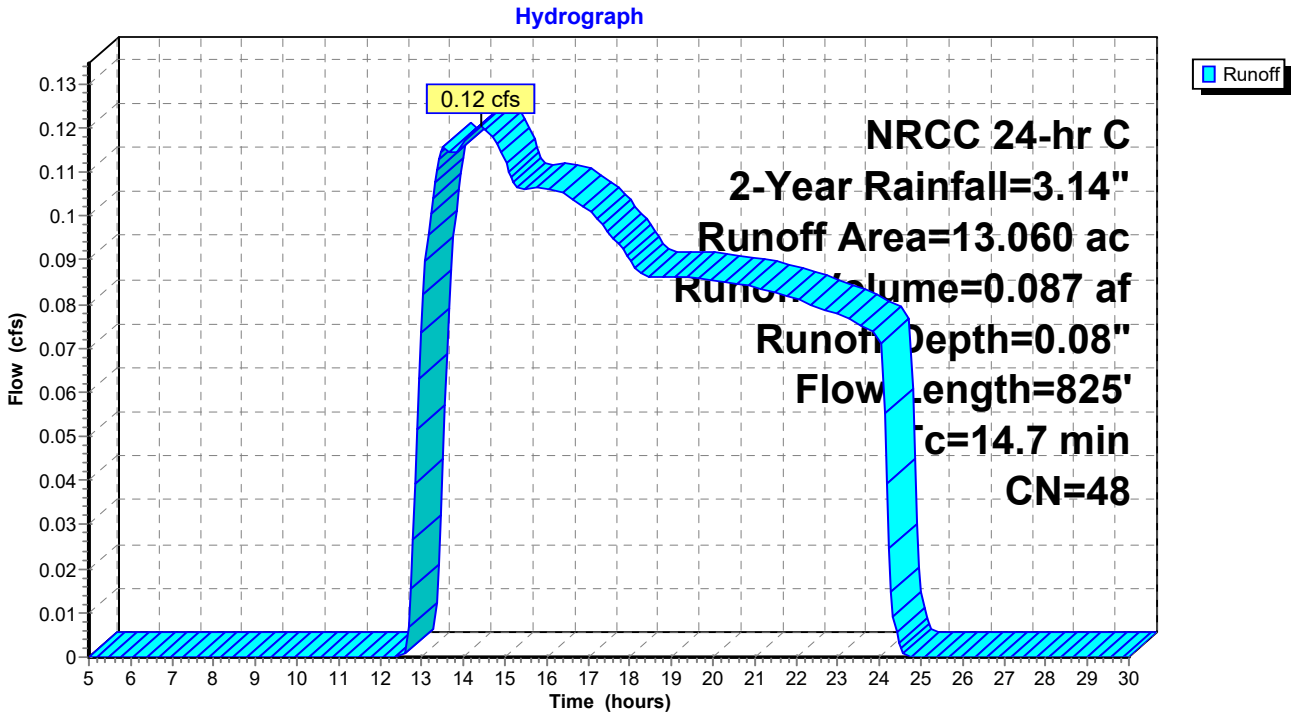
Runoff = 0.12 cfs @ 14.41 hrs, Volume= 0.087 af, Depth= 0.08"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 2-Year Rainfall=3.14"

	Area (ac)	CN	Description
*	0.060	98	Impervious surfaces
*	1.860	39	Open Space - Good cond - A soils
*	7.710	36	
*	3.430	79	
	13.060	48	Weighted Average
	13.000		99.54% Pervious Area
	0.060		0.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
7.2	425	0.0200	0.99		**Shallow Concentrated Flow, Shallow Concentrated** Short Grass Pasture Kv= 7.0 fps
1.2	350	0.0300	4.91	9.82	**Channel Flow, Channel flow** Area= 2.0 sf Perim= 3.0' r= 0.67' n= 0.040 Winding stream, pools & shoals
14.7	825	Total			

Subcatchment 2: Area 2



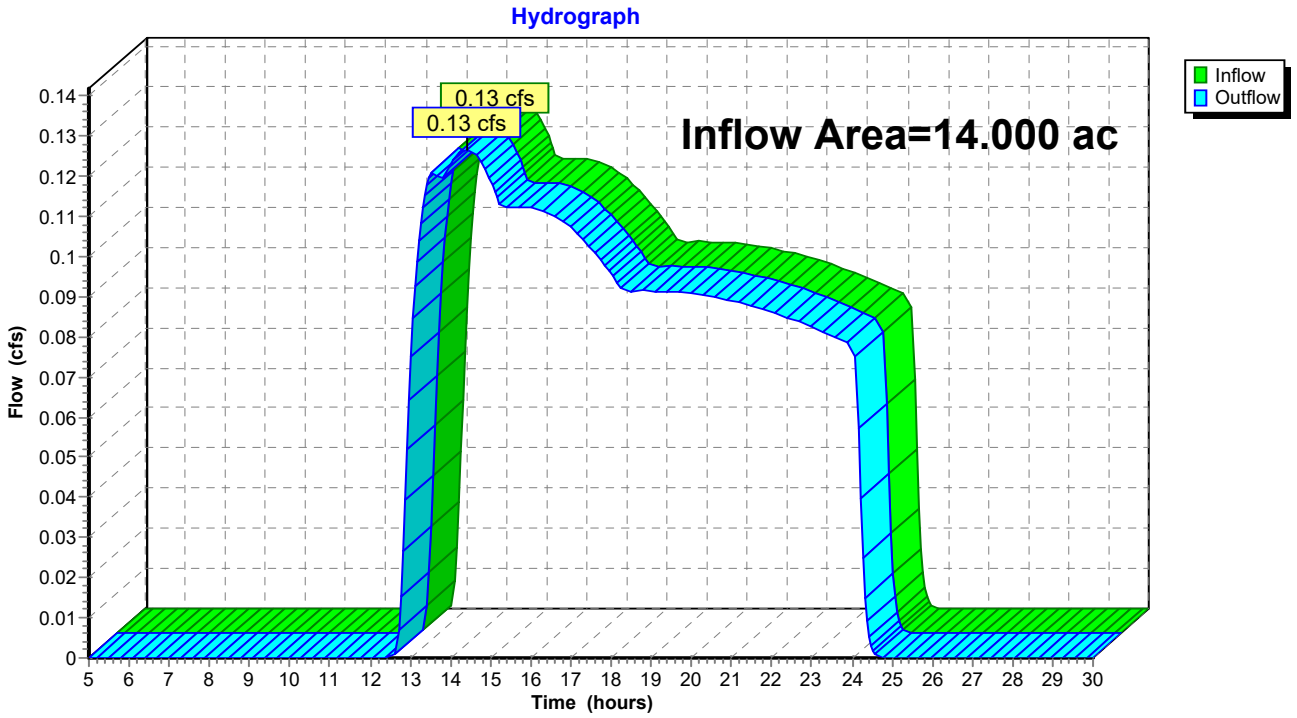
Summary for Reach 3R: To Stream

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

Inflow Area = 14.000 ac, 1.43% Impervious, Inflow Depth = 0.08" for 2-Year event
Inflow = 0.13 cfs @ 14.42 hrs, Volume= 0.092 af
Outflow = 0.13 cfs @ 14.42 hrs, Volume= 0.092 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs

Reach 3R: To Stream



Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1: Area1 Runoff Area=0.940 ac 14.89% Impervious Runoff Depth=0.49"
Flow Length=225' Tc=9.2 min CN=47 Runoff=0.24 cfs 0.039 af

Subcatchment2: Area2 Runoff Area=13.060 ac 0.46% Impervious Runoff Depth=0.54"
Flow Length=825' Tc=14.7 min CN=48 Runoff=3.34 cfs 0.588 af

Reach3R: To Stream Inflow=3.54 cfs 0.626 af
Outflow=3.54 cfs 0.626 af

Total Runoff Area = 14.000 ac Runoff Volume = 0.626 af Average Runoff Depth = 0.54"
98.57% Pervious = 13.800 ac 1.43% Impervious = 0.200 ac

Summary for Subcatchment 1: Area 1

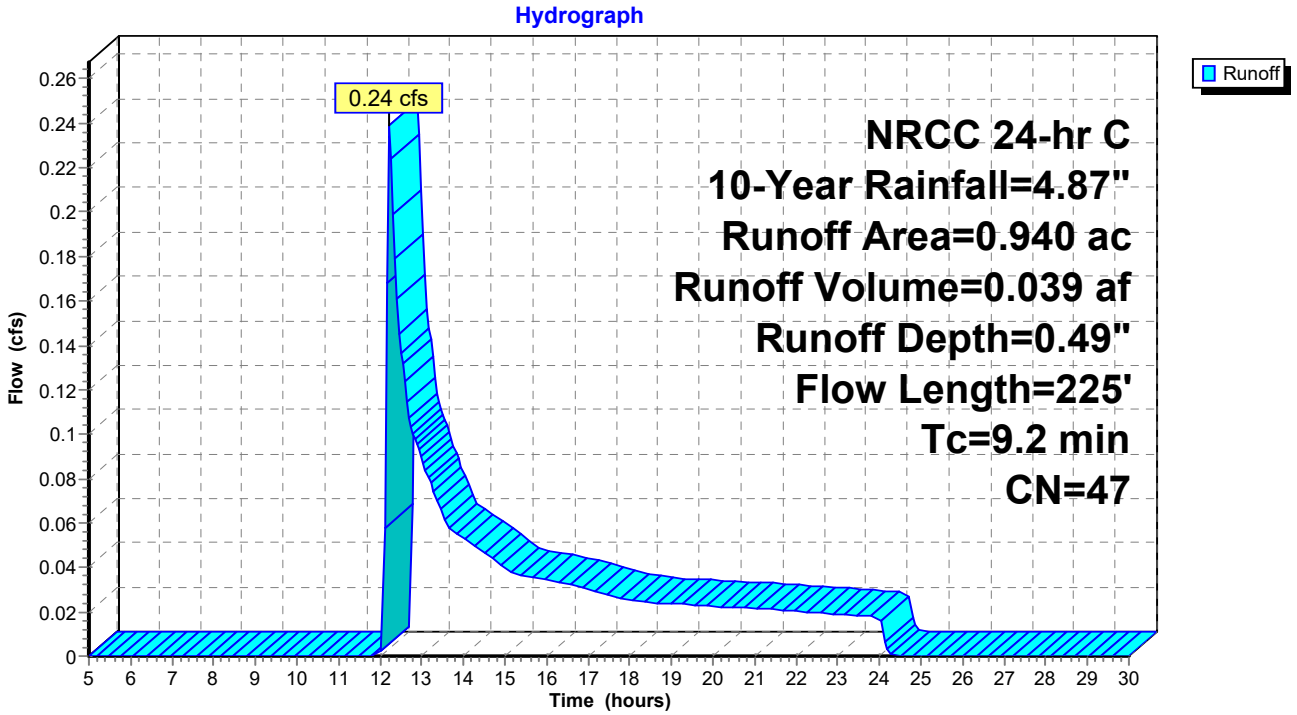
Runoff = 0.24 cfs @ 12.22 hrs, Volume= 0.039 af, Depth= 0.49"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 10-Year Rainfall=4.87"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.690	39	Open Space - good - A soils
*	0.110	36	Woods - fair - A soils
	0.940	47	Weighted Average
	0.800		85.11% Pervious Area
	0.140		14.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
2.9	175	0.0200	0.99		**Shallow Concentrated Flow, Shallow concentrated flow** Short Grass Pasture Kv= 7.0 fps
9.2	225	Total			

Subcatchment 1: Area 1



Summary for Subcatchment 2: Area 2

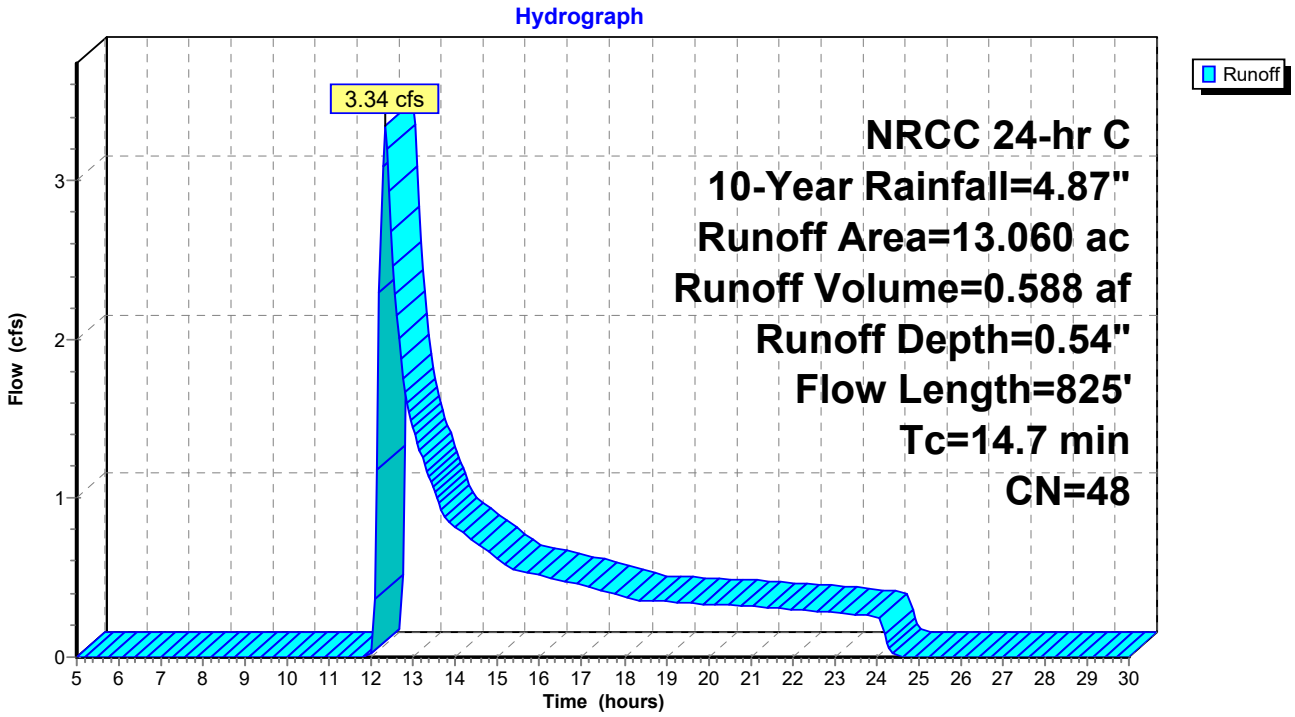
Runoff = 3.34 cfs @ 12.31 hrs, Volume= 0.588 af, Depth= 0.54"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 10-Year Rainfall=4.87"

	Area (ac)	CN	Description
*	0.060	98	Impervious surfaces
*	1.860	39	Open Space - Good cond - A soils
*	7.710	36	
*	3.430	79	
	13.060	48	Weighted Average
	13.000		99.54% Pervious Area
	0.060		0.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
7.2	425	0.0200	0.99		**Shallow Concentrated Flow, Shallow Concentrated** Short Grass Pasture Kv= 7.0 fps
1.2	350	0.0300	4.91	9.82	**Channel Flow, Channel flow** Area= 2.0 sf Perim= 3.0' r= 0.67' n= 0.040 Winding stream, pools & shoals
14.7	825	Total			

Subcatchment 2: Area 2



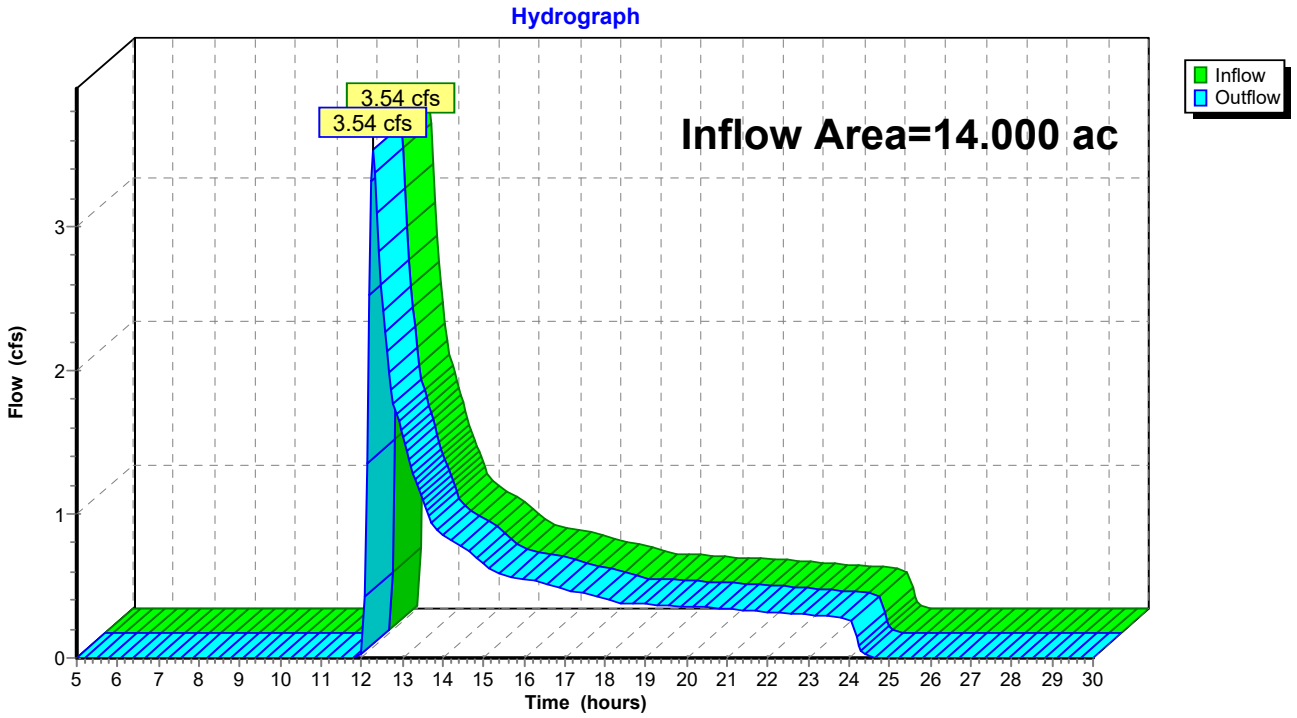
Summary for Reach 3R: To Stream

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

Inflow Area = 14.000 ac, 1.43% Impervious, Inflow Depth = 0.54" for 10-Year event
Inflow = 3.54 cfs @ 12.30 hrs, Volume= 0.626 af
Outflow = 3.54 cfs @ 12.30 hrs, Volume= 0.626 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs

Reach 3R: To Stream



Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1: Area1 Runoff Area=0.940 ac 14.89% Impervious Runoff Depth=0.91"
Flow Length=225' Tc=9.2 min CN=47 Runoff=0.68 cfs 0.071 af

Subcatchment2: Area2 Runoff Area=13.060 ac 0.46% Impervious Runoff Depth=0.98"
Flow Length=825' Tc=14.7 min CN=48 Runoff=8.65 cfs 1.066 af

Reach3R: To Stream Inflow=9.19 cfs 1.137 af
Outflow=9.19 cfs 1.137 af

Total Runoff Area = 14.000 ac Runoff Volume = 1.137 af Average Runoff Depth = 0.97"
98.57% Pervious = 13.800 ac 1.43% Impervious = 0.200 ac

Summary for Subcatchment 1: Area 1

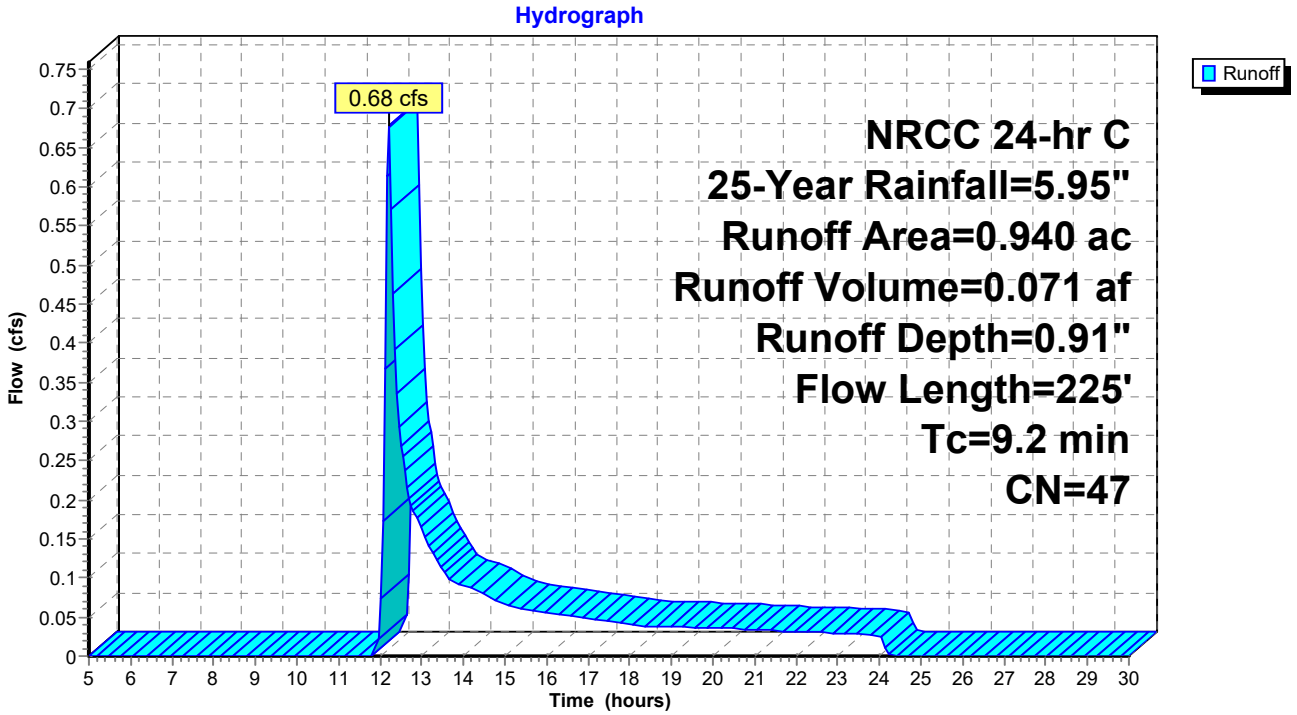
Runoff = 0.68 cfs @ 12.19 hrs, Volume= 0.071 af, Depth= 0.91"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 25-Year Rainfall=5.95"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.690	39	Open Space - good - A soils
*	0.110	36	Woods - fair - A soils
	0.940	47	Weighted Average
	0.800		85.11% Pervious Area
	0.140		14.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
2.9	175	0.0200	0.99		**Shallow Concentrated Flow, Shallow concentrated flow** Short Grass Pasture Kv= 7.0 fps
9.2	225	Total			

Subcatchment 1: Area 1



Summary for Subcatchment 2: Area 2

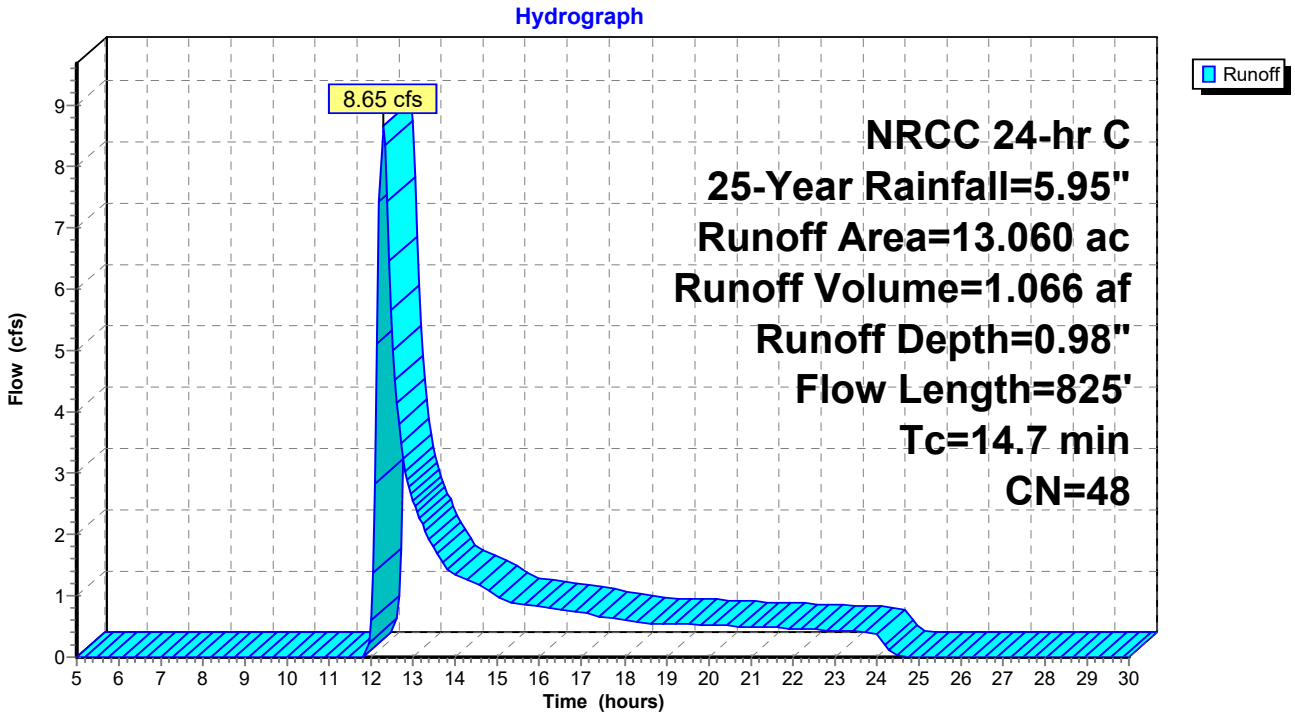
Runoff = 8.65 cfs @ 12.27 hrs, Volume= 1.066 af, Depth= 0.98"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 25-Year Rainfall=5.95"

	Area (ac)	CN	Description
*	0.060	98	Impervious surfaces
*	1.860	39	Open Space - Good cond - A soils
*	7.710	36	
*	3.430	79	
	13.060	48	Weighted Average
	13.000		99.54% Pervious Area
	0.060		0.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
7.2	425	0.0200	0.99		**Shallow Concentrated Flow, Shallow Concentrated** Short Grass Pasture Kv= 7.0 fps
1.2	350	0.0300	4.91	9.82	**Channel Flow, Channel flow** Area= 2.0 sf Perim= 3.0' r= 0.67' n= 0.040 Winding stream, pools & shoals
14.7	825	Total			

Subcatchment 2: Area 2



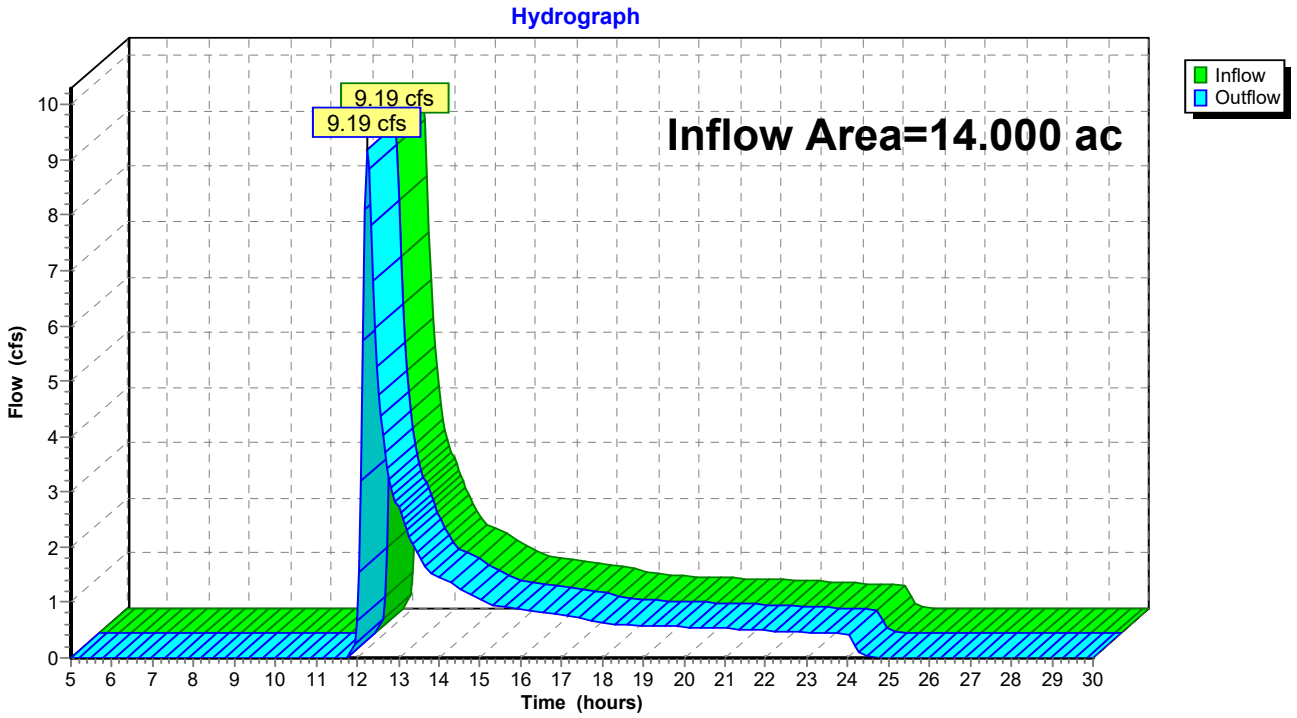
Summary for Reach 3R: To Stream

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

Inflow Area = 14.000 ac, 1.43% Impervious, Inflow Depth = 0.97" for 25-Year event
Inflow = 9.19 cfs @ 12.26 hrs, Volume= 1.137 af
Outflow = 9.19 cfs @ 12.26 hrs, Volume= 1.137 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs

Reach 3R: To Stream



Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1: Area1 Runoff Area=0.940 ac 14.89% Impervious Runoff Depth=1.72"
Flow Length=225' Tc=9.2 min CN=47 Runoff=1.55 cfs 0.135 af

Subcatchment2: Area2 Runoff Area=13.060 ac 0.46% Impervious Runoff Depth=1.82"
Flow Length=825' Tc=14.7 min CN=48 Runoff=19.21 cfs 1.981 af

Reach3R: To Stream Inflow=20.44 cfs 2.116 af
Outflow=20.44 cfs 2.116 af

Total Runoff Area = 14.000 ac Runoff Volume = 2.116 af Average Runoff Depth = 1.81"
98.57% Pervious = 13.800 ac 1.43% Impervious = 0.200 ac

Summary for Subcatchment 1: Area 1

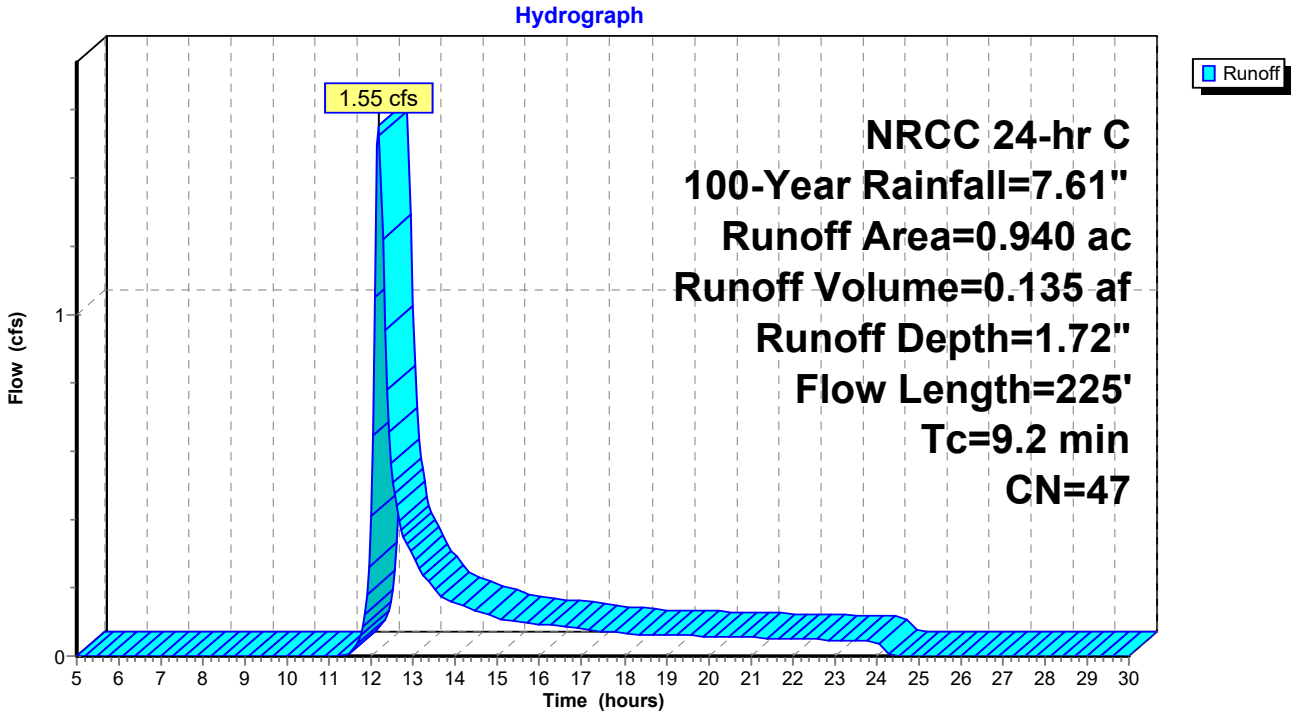
Runoff = 1.55 cfs @ 12.18 hrs, Volume= 0.135 af, Depth= 1.72"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 100-Year Rainfall=7.61"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.690	39	Open Space - good - A soils
*	0.110	36	Woods - fair - A soils
	0.940	47	Weighted Average
	0.800		85.11% Pervious Area
	0.140		14.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
2.9	175	0.0200	0.99		**Shallow Concentrated Flow, Shallow concentrated flow** Short Grass Pasture Kv= 7.0 fps
9.2	225	Total			

Subcatchment 1: Area 1



Summary for Subcatchment 2: Area 2

[47] Hint: Peak is 196% of capacity of segment #3

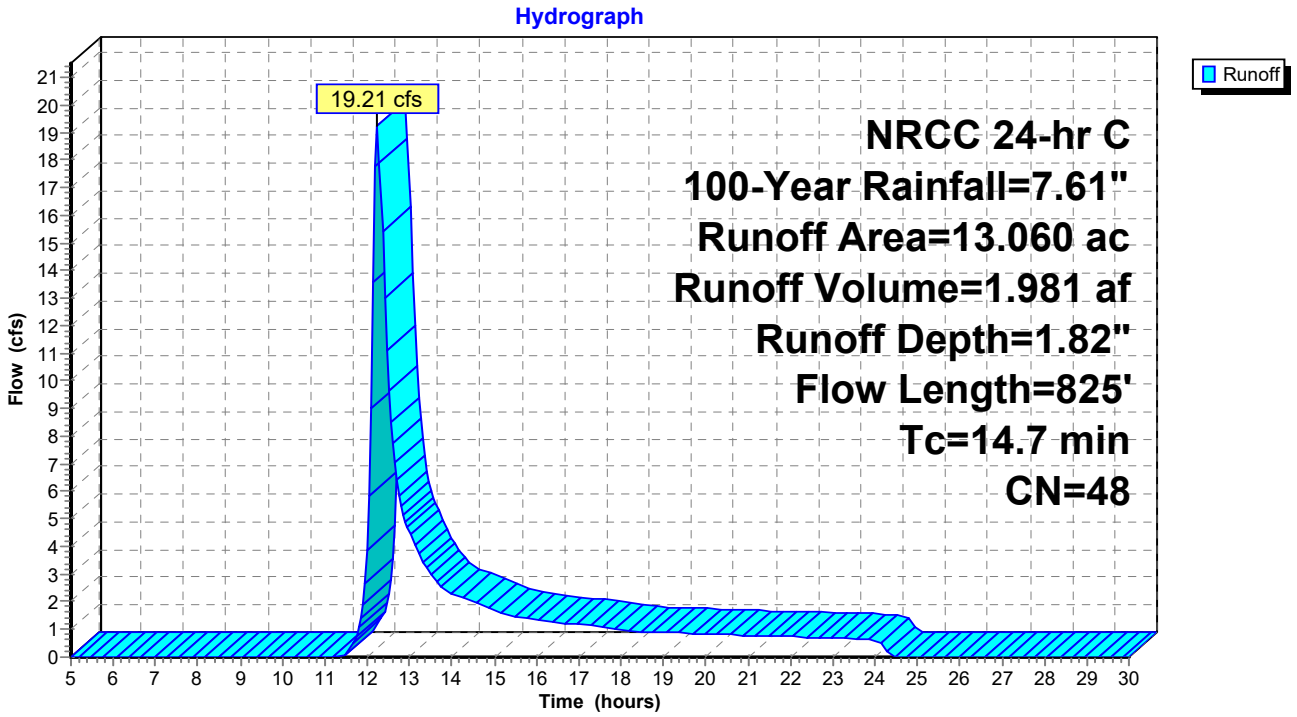
Runoff = 19.21 cfs @ 12.25 hrs, Volume= 1.981 af, Depth= 1.82"
Routed to Reach 3R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 100-Year Rainfall=7.61"

	Area (ac)	CN	Description
*	0.060	98	Impervious surfaces
*	1.860	39	Open Space - Good cond - A soils
*	7.710	36	
*	3.430	79	
	13.060	48	Weighted Average
	13.000		99.54% Pervious Area
	0.060		0.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
7.2	425	0.0200	0.99		**Shallow Concentrated Flow, Shallow Concentrated** Short Grass Pasture Kv= 7.0 fps
1.2	350	0.0300	4.91	9.82	**Channel Flow, Channel flow** Area= 2.0 sf Perim= 3.0' r= 0.67' n= 0.040 Winding stream, pools & shoals
14.7	825	Total			

Subcatchment 2: Area 2



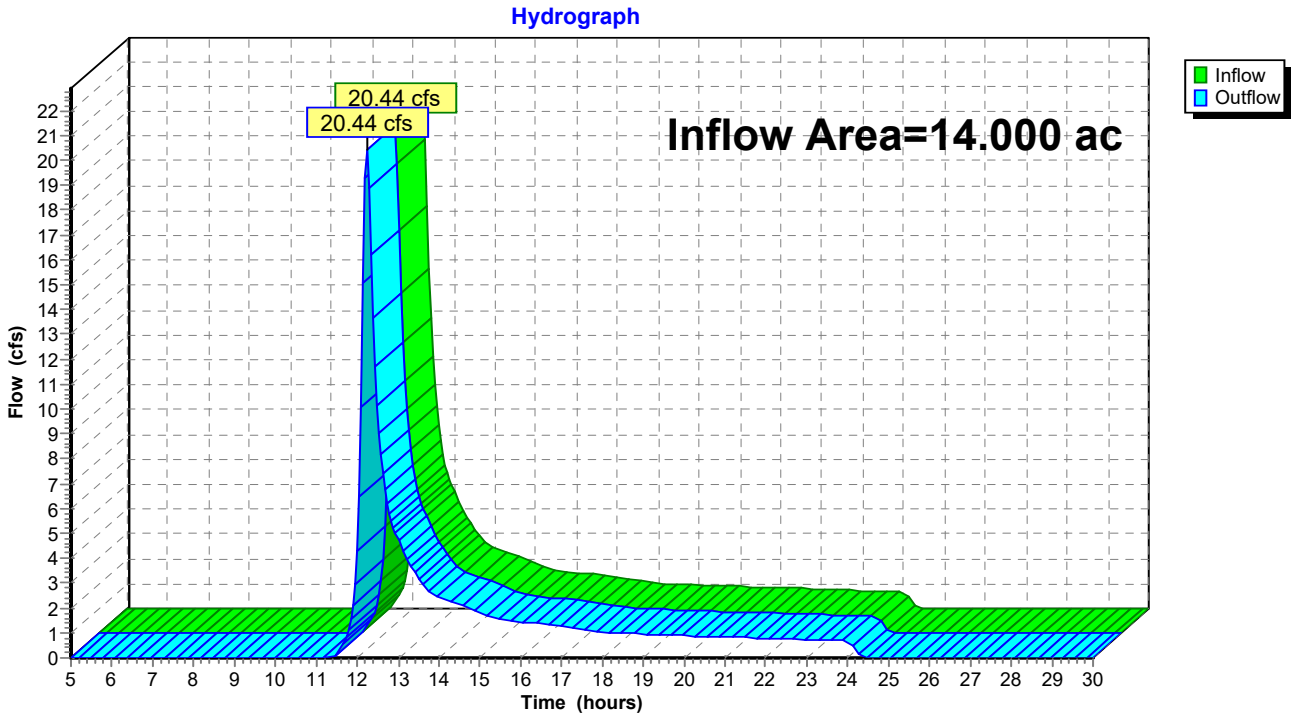
Summary for Reach 3R: To Stream

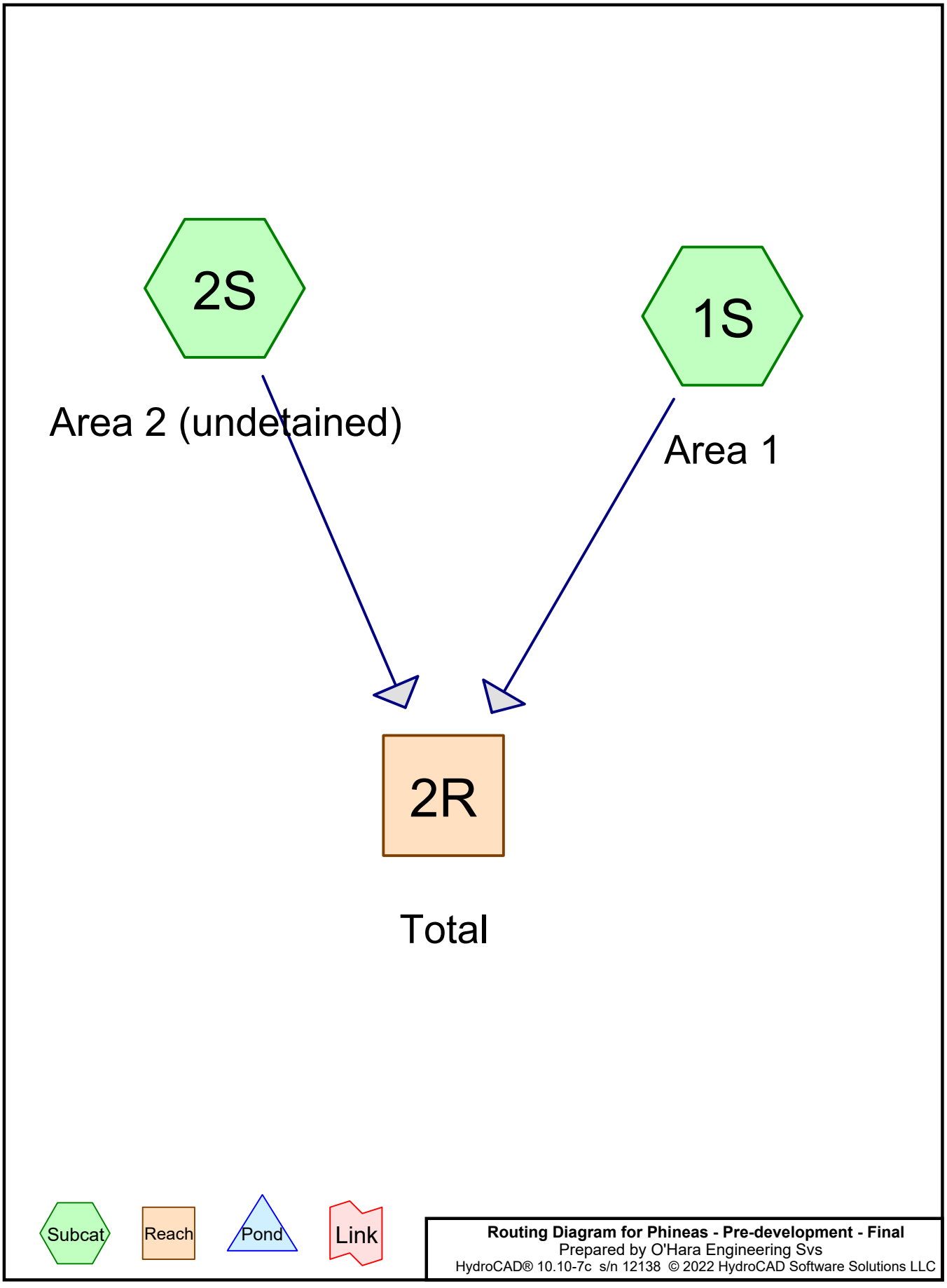
[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 14.000 ac, 1.43% Impervious, Inflow Depth = 1.81" for 100-Year event
Inflow = 20.44 cfs @ 12.25 hrs, Volume= 2.116 af
Outflow = 20.44 cfs @ 12.25 hrs, Volume= 2.116 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs

Reach 3R: To Stream





Routing Diagram for Phineas - Pre-development - Final
Prepared by O'Hara Engineering Svs
HydroCAD® 10.10-7c s/n 12138 © 2022 HydroCAD Software Solutions LLC

Project Notes

Rainfall events imported from "NRCS-Rain.txt" for 4079 MA Dracut Middlesex County North
Rainfall events imported from "Phineas - Pre-Development.hcp"

Phineas - Pre-development - Final

Prepared by O'Hara Engineering Svs

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	NRCC 24-hr	C	Default	24.00	1	3.14	2
2	10-Year	NRCC 24-hr	C	Default	24.00	1	4.87	2
3	25-Year	NRCC 24-hr	C	Default	24.00	1	5.95	2
4	100-Year	NRCC 24-hr	C	Default	24.00	1	7.61	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.140	98	Impervious Surfaces (1S)
0.730	39	Open Space - good - A soils (1S)
1.860	39	Pasture/grassland/range, Good, HSG A (2S)
0.060	98	Paved parking, HSG A (2S)
7.710	36	Woods, Fair, HSG A (2S)
10.270	79	Woods, Fair, HSG D (2S)
0.080	43	Woods/grass comb., Fair, HSG A (1S)
20.850	**58**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
9.710	HSG A	1S, 2S
0.000	HSG B	
0.000	HSG C	
10.270	HSG D	2S
0.870	Other	1S
20.850		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	0.140	0.140	Impervious Surfaces	1S
0.000	0.000	0.000	0.000	0.730	0.730	Open Space - good - A soils	1S
1.860	0.000	0.000	0.000	0.000	1.860	Pasture/grassland/range, Good	2S
0.060	0.000	0.000	0.000	0.000	0.060	Paved parking	2S
7.710	0.000	0.000	10.270	0.000	17.980	Woods, Fair	2S
0.080	0.000	0.000	0.000	0.000	0.080	Woods/grass comb., Fair	1S
9.710	**0.000**	**0.000**	**10.270**	**0.870**	**20.850**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)
1	1S	0.00	0.00	125.0	0.0500	0.015	0.0	12.0	4.0

Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.950 ac 14.74% Impervious Runoff Depth>0.08"
Flow Length=175' Tc=6.6 min CN=48 Runoff=0.01 cfs 0.006 af

Subcatchment2S: Area2 (undetained) Runoff Area=19.900 ac 0.30% Impervious Runoff Depth>0.35"
Flow Length=425' Tc=13.4 min CN=59 Runoff=3.48 cfs 0.580 af

Reach2R: Total Inflow=3.48 cfs 0.586 af
Outflow=3.48 cfs 0.586 af

Total Runoff Area = 20.850 ac Runoff Volume = 0.586 af Average Runoff Depth = 0.34"
99.04% Pervious = 20.650 ac 0.96% Impervious = 0.200 ac

Summary for Subcatchment 1S: Area 1

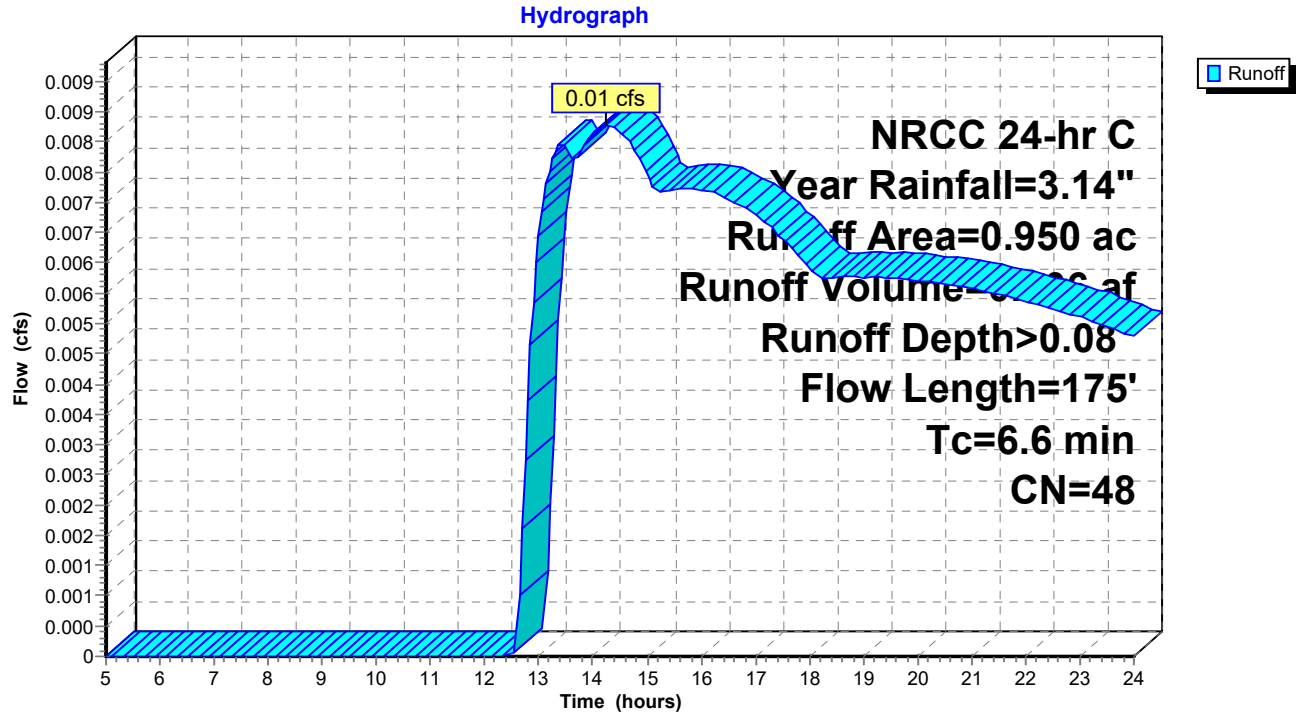
Runoff = 0.01 cfs @ 14.26 hrs, Volume= 0.006 af, Depth> 0.08"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 2-Year Rainfall=3.14"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.730	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.950	48	Weighted Average
	0.810		85.26% Pervious Area
	0.140		14.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S: Area 2 (undetained)

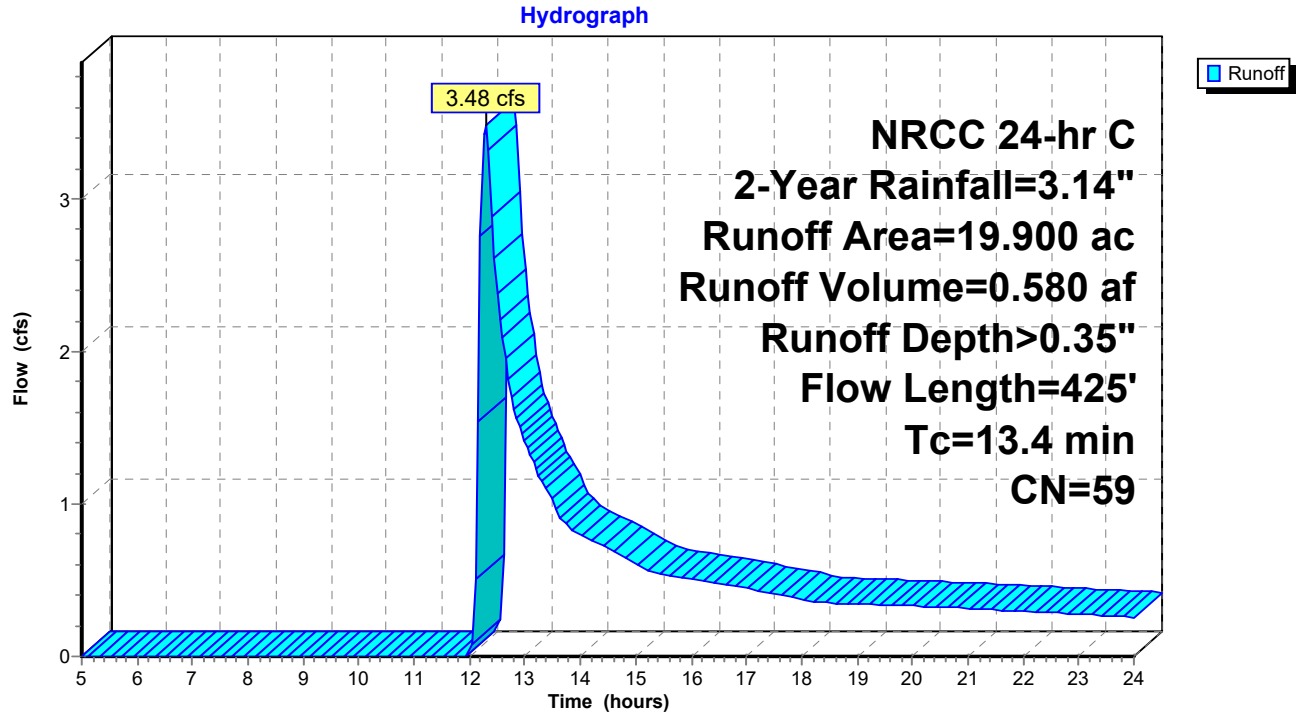
Runoff = 3.48 cfs @ 12.28 hrs, Volume= 0.580 af, Depth> 0.35"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 2-Year Rainfall=3.14"

Area (ac)	CN	Description
0.060	98	Paved parking, HSG A
1.860	39	Pasture/grassland/range, Good, HSG A
7.710	36	Woods, Fair, HSG A
10.270	79	Woods, Fair, HSG D
19.900	59	Weighted Average
19.840		99.70% Pervious Area
0.060		0.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	50	0.0200	0.10		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
13.4	425	Total			

Subcatchment 2S: Area 2 (undetained)



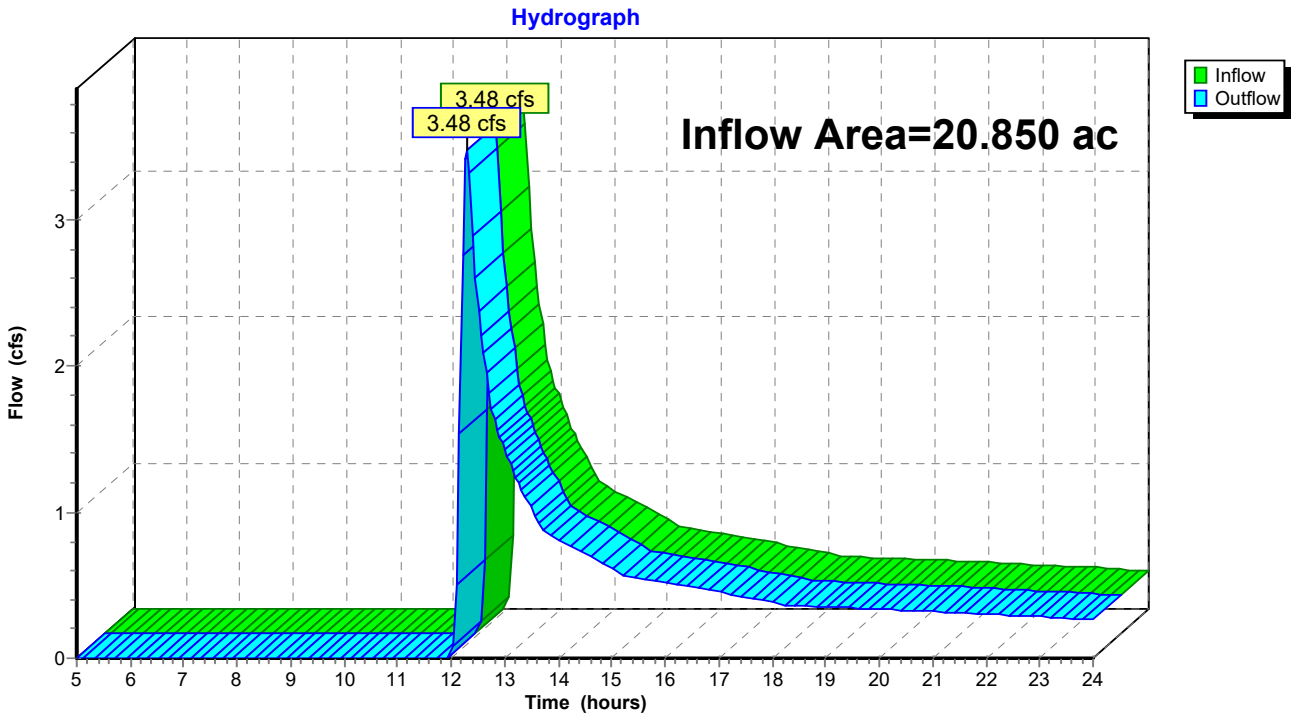
Summary for Reach 2R: Total

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

Inflow Area = 20.850 ac, 0.96% Impervious, Inflow Depth > 0.34" for 2-Year event
Inflow = 3.48 cfs @ 12.28 hrs, Volume= 0.586 af
Outflow = 3.48 cfs @ 12.28 hrs, Volume= 0.586 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: Total



Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.950 ac 14.74% Impervious Runoff Depth>0.54"
Flow Length=175' Tc=6.6 min CN=48 Runoff=0.34 cfs 0.043 af

Subcatchment2S: Area2 (undetained) Runoff Area=19.900 ac 0.30% Impervious Runoff Depth>1.16"
Flow Length=425' Tc=13.4 min CN=59 Runoff=19.39 cfs 1.917 af

Reach2R: Total Inflow=19.66 cfs 1.959 af
Outflow=19.66 cfs 1.959 af

Total Runoff Area = 20.850 ac Runoff Volume = 1.959 af Average Runoff Depth = 1.13"
99.04% Pervious = 20.650 ac 0.96% Impervious = 0.200 ac

Summary for Subcatchment 1S: Area 1

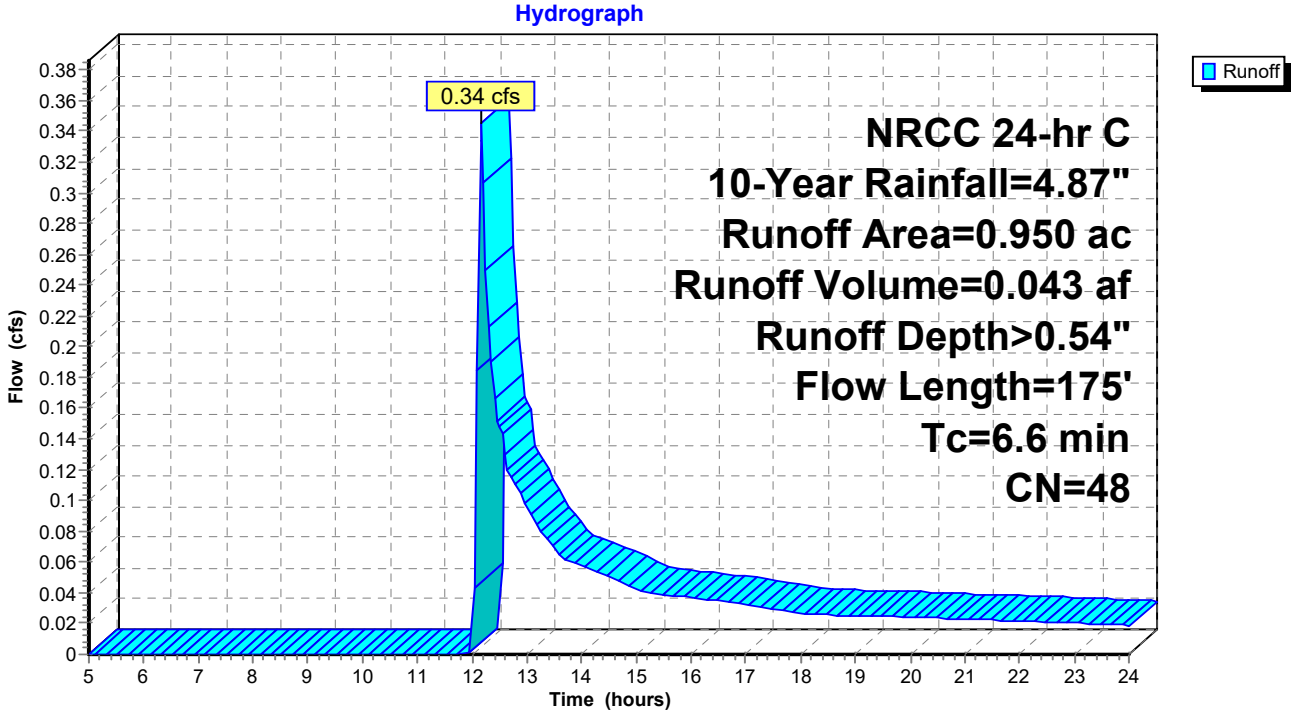
Runoff = 0.34 cfs @ 12.17 hrs, Volume= 0.043 af, Depth> 0.54"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 10-Year Rainfall=4.87"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.730	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.950	48	Weighted Average
	0.810		85.26% Pervious Area
	0.140		14.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S: Area 2 (undetained)

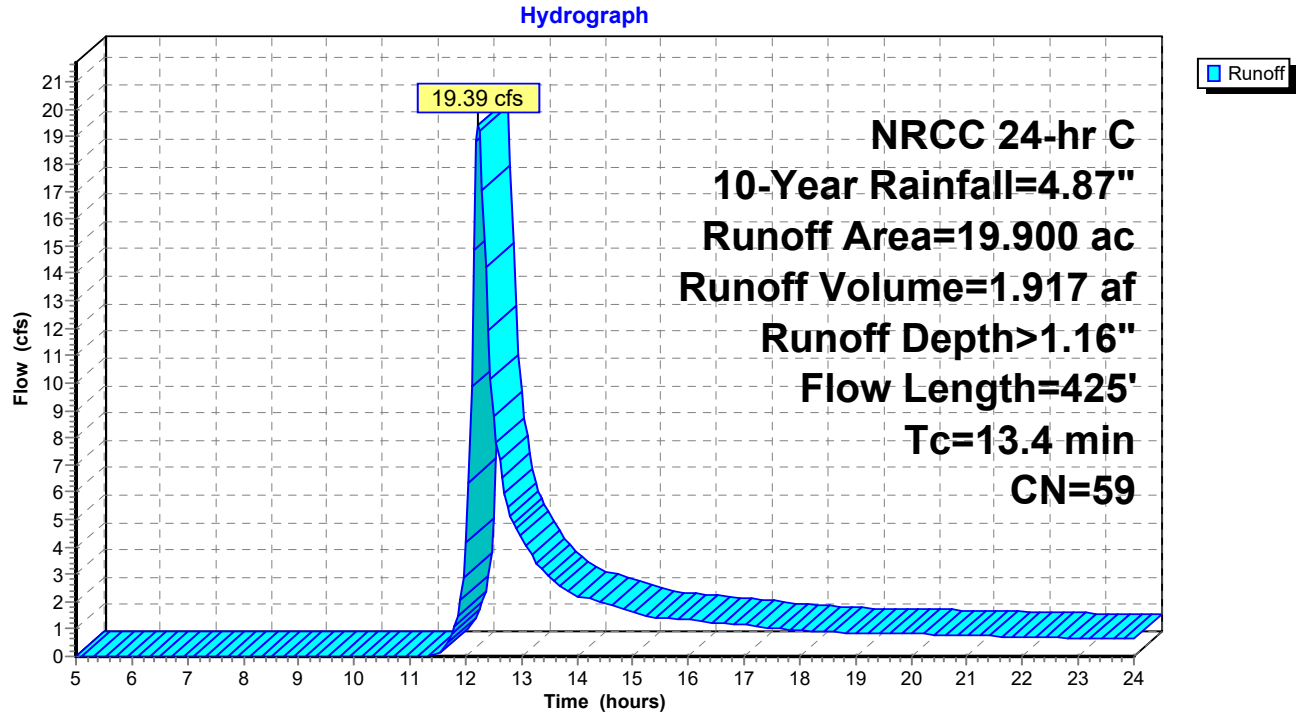
Runoff = 19.39 cfs @ 12.23 hrs, Volume= 1.917 af, Depth> 1.16"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 10-Year Rainfall=4.87"

Area (ac)	CN	Description
0.060	98	Paved parking, HSG A
1.860	39	Pasture/grassland/range, Good, HSG A
7.710	36	Woods, Fair, HSG A
10.270	79	Woods, Fair, HSG D
19.900	59	Weighted Average
19.840		99.70% Pervious Area
0.060		0.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	50	0.0200	0.10		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
13.4	425	Total			

Subcatchment 2S: Area 2 (undetained)



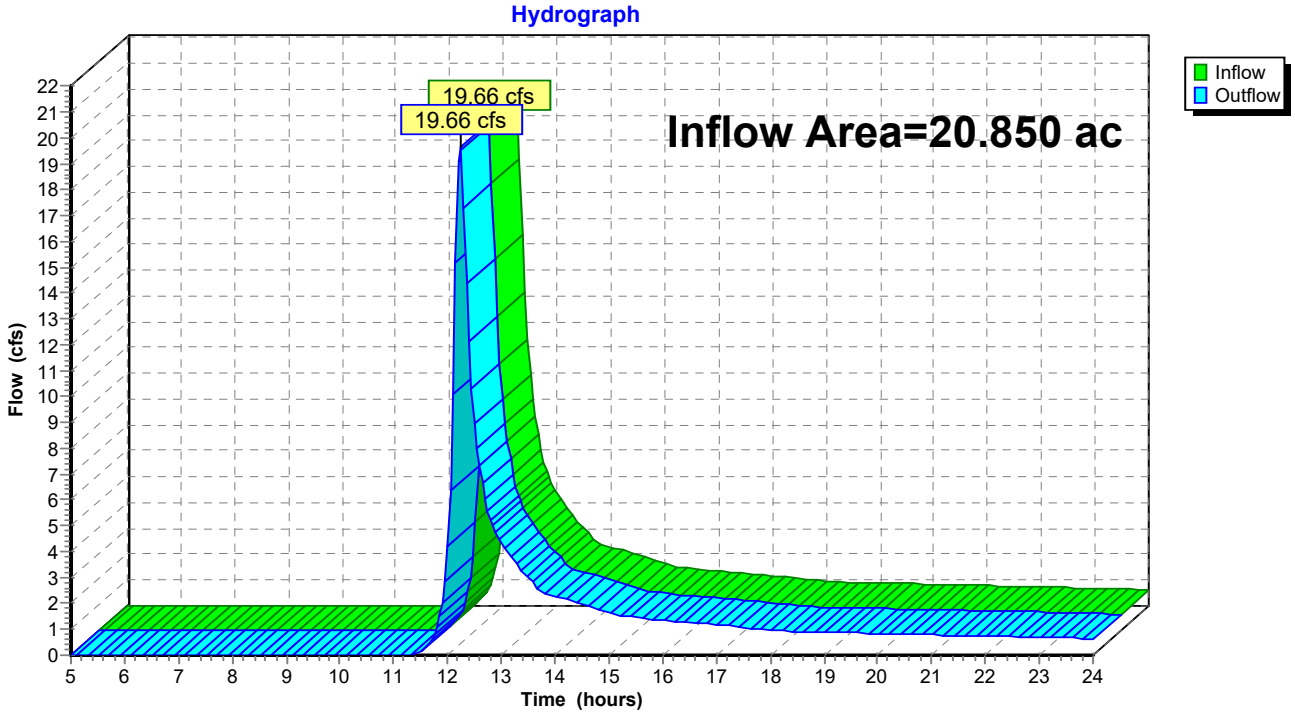
Summary for Reach 2R: Total

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

Inflow Area = 20.850 ac, 0.96% Impervious, Inflow Depth > 1.13" for 10-Year event
Inflow = 19.66 cfs @ 12.23 hrs, Volume= 1.959 af
Outflow = 19.66 cfs @ 12.23 hrs, Volume= 1.959 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: Total



Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.950 ac 14.74% Impervious Runoff Depth>0.98"
Flow Length=175' Tc=6.6 min CN=48 Runoff=0.89 cfs 0.077 af

Subcatchment2S: Area2 (undetained) Runoff Area=19.900 ac 0.30% Impervious Runoff Depth>1.80"
Flow Length=425' Tc=13.4 min CN=59 Runoff=32.15 cfs 2.983 af

Reach2R: Total Inflow=32.98 cfs 3.061 af
Outflow=32.98 cfs 3.061 af

Total Runoff Area = 20.850 ac Runoff Volume = 3.061 af Average Runoff Depth = 1.76"
99.04% Pervious = 20.650 ac 0.96% Impervious = 0.200 ac

Summary for Subcatchment 1S: Area 1

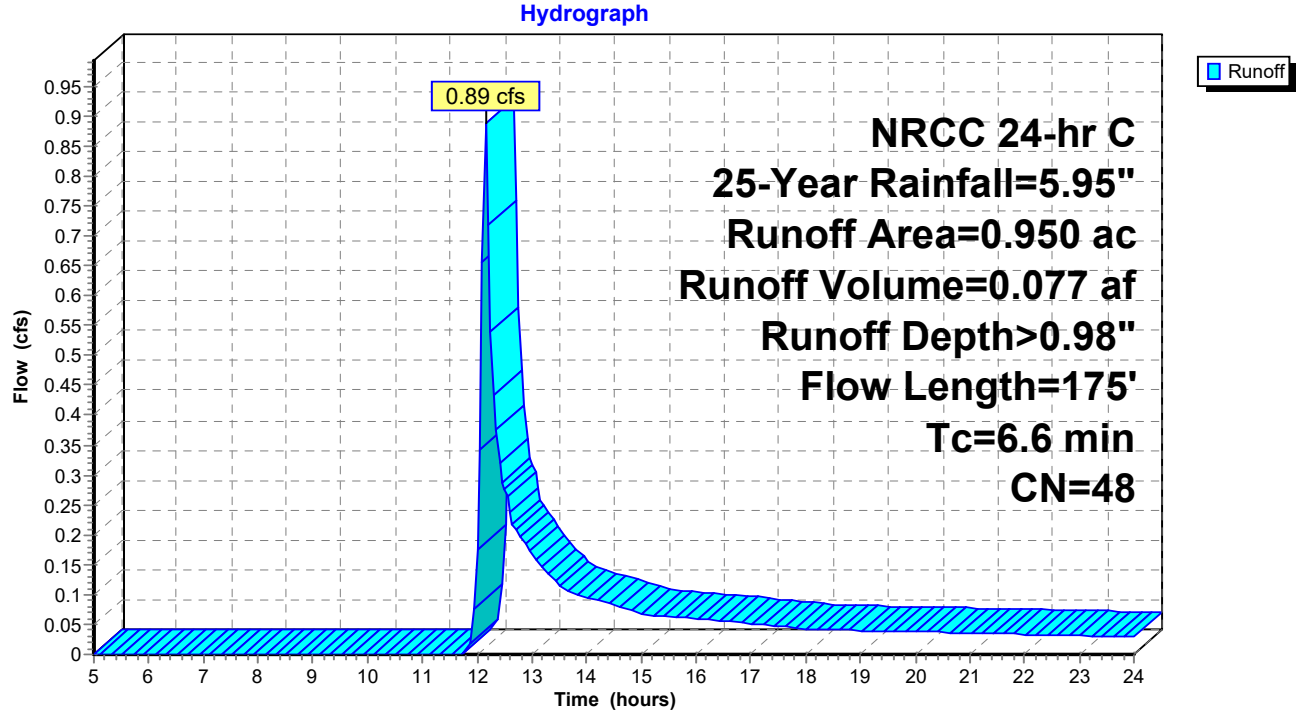
Runoff = 0.89 cfs @ 12.15 hrs, Volume= 0.077 af, Depth> 0.98"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 25-Year Rainfall=5.95"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.730	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.950	48	Weighted Average
	0.810		85.26% Pervious Area
	0.140		14.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S: Area 2 (undetained)

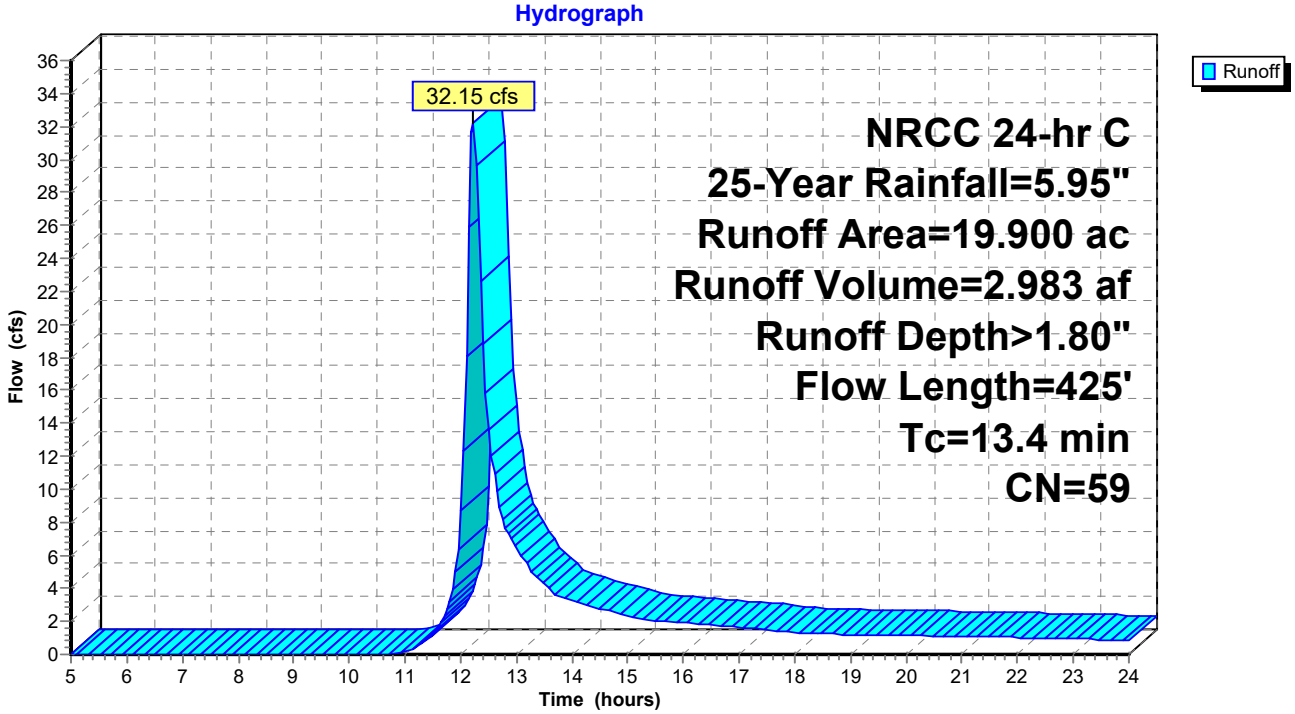
Runoff = 32.15 cfs @ 12.23 hrs, Volume= 2.983 af, Depth> 1.80"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 25-Year Rainfall=5.95"

Area (ac)	CN	Description
0.060	98	Paved parking, HSG A
1.860	39	Pasture/grassland/range, Good, HSG A
7.710	36	Woods, Fair, HSG A
10.270	79	Woods, Fair, HSG D
19.900	59	Weighted Average
19.840		99.70% Pervious Area
0.060		0.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	50	0.0200	0.10		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
13.4	425	Total			

Subcatchment 2S: Area 2 (undetained)



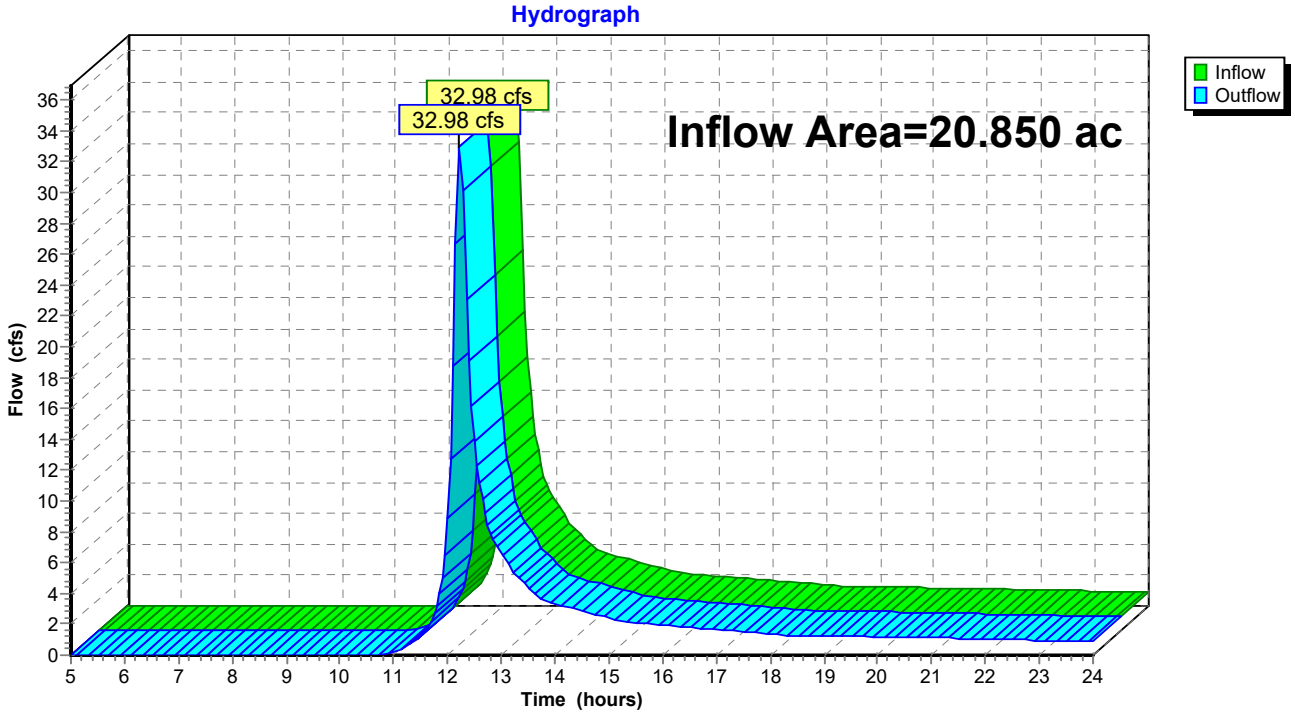
Summary for Reach 2R: Total

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

Inflow Area = 20.850 ac, 0.96% Impervious, Inflow Depth > 1.76" for 25-Year event
Inflow = 32.98 cfs @ 12.22 hrs, Volume= 3.061 af
Outflow = 32.98 cfs @ 12.22 hrs, Volume= 3.061 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: Total



Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.950 ac 14.74% Impervious Runoff Depth>1.82"
Flow Length=175' Tc=6.6 min CN=48 Runoff=1.92 cfs 0.144 af

Subcatchment2S: Area2 (undetained) Runoff Area=19.900 ac 0.30% Impervious Runoff Depth>2.93"
Flow Length=425' Tc=13.4 min CN=59 Runoff=54.65 cfs 4.853 af

Reach2R: Total Inflow=55.97 cfs 4.997 af
Outflow=55.97 cfs 4.997 af

Total Runoff Area = 20.850 ac Runoff Volume = 4.997 af Average Runoff Depth = 2.88"
99.04% Pervious = 20.650 ac 0.96% Impervious = 0.200 ac

Summary for Subcatchment 1S: Area 1

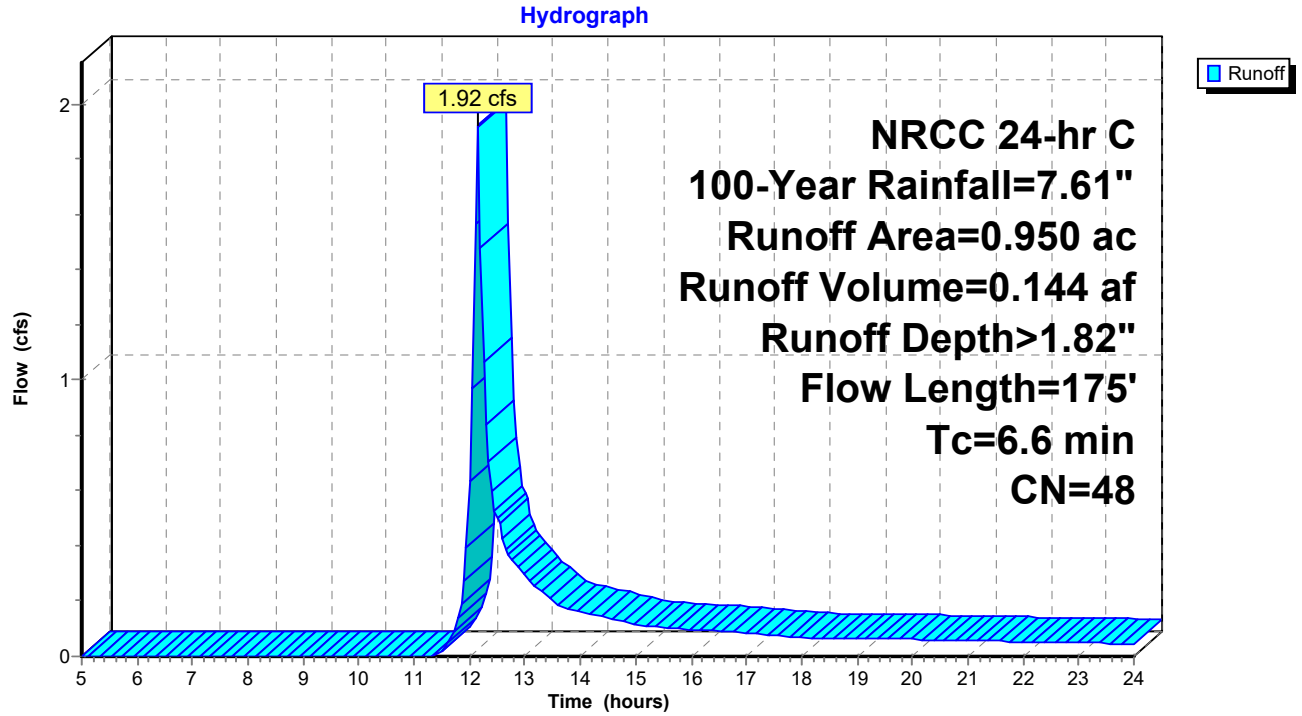
Runoff = 1.92 cfs @ 12.15 hrs, Volume= 0.144 af, Depth> 1.82"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 100-Year Rainfall=7.61"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.730	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.950	48	Weighted Average
	0.810		85.26% Pervious Area
	0.140		14.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S: Area 2 (undetained)

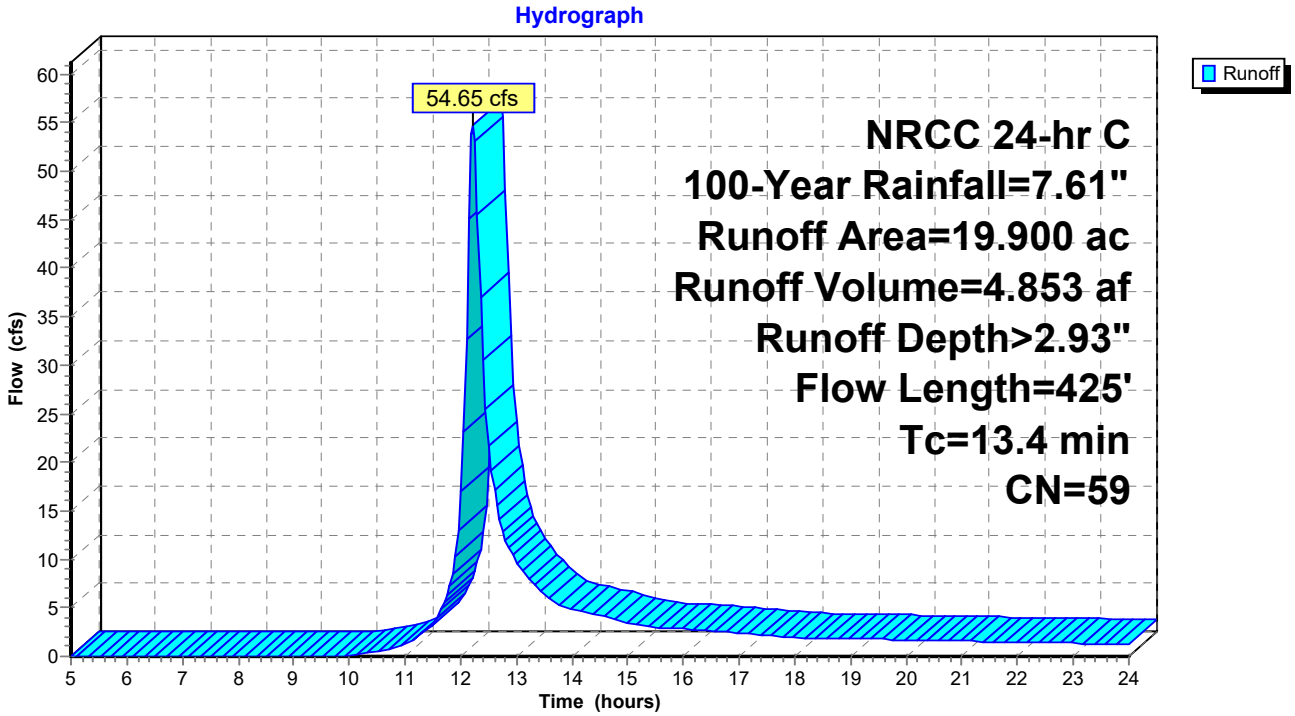
Runoff = 54.65 cfs @ 12.22 hrs, Volume= 4.853 af, Depth> 2.93"
Routed to Reach 2R : Total

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 100-Year Rainfall=7.61"

Area (ac)	CN	Description
0.060	98	Paved parking, HSG A
1.860	39	Pasture/grassland/range, Good, HSG A
7.710	36	Woods, Fair, HSG A
10.270	79	Woods, Fair, HSG D
19.900	59	Weighted Average
19.840		99.70% Pervious Area
0.060		0.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.3	50	0.0200	0.10		**Sheet Flow, sheet flow** Grass: Dense n= 0.240 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
13.4	425	Total			

Subcatchment 2S: Area 2 (undetained)



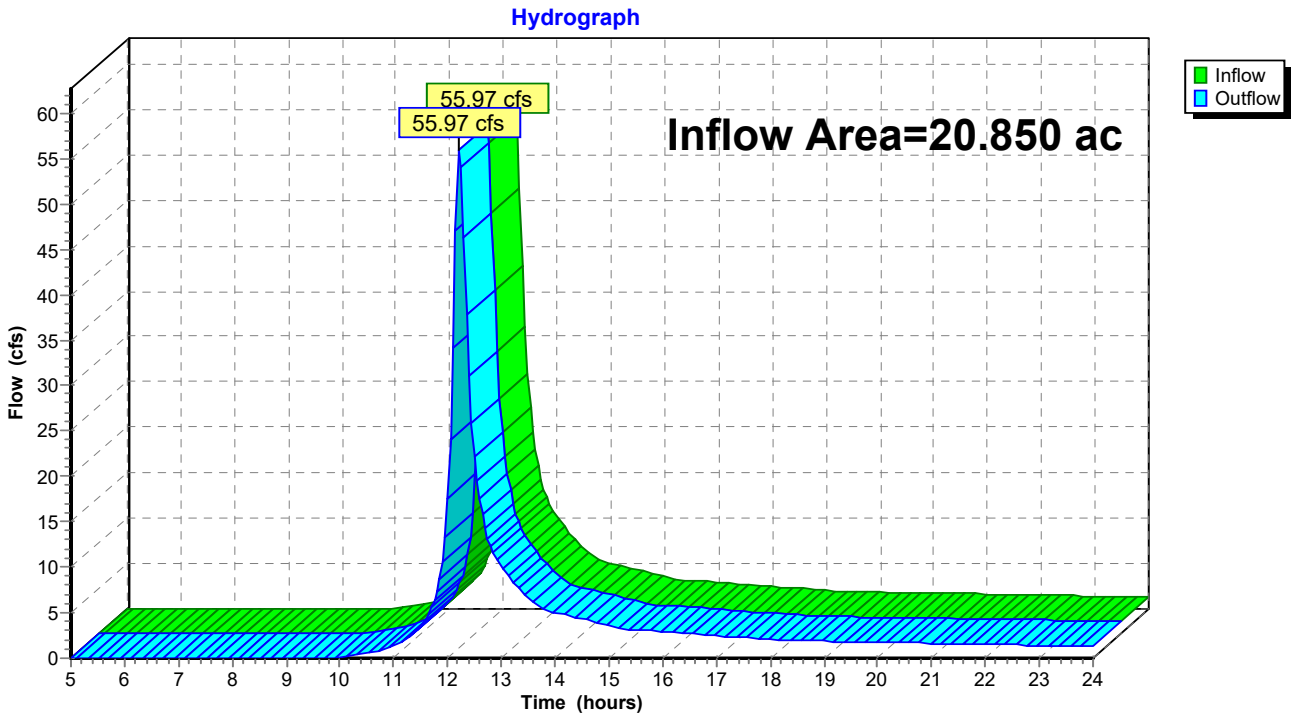
Summary for Reach 2R: Total

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

Inflow Area = 20.850 ac, 0.96% Impervious, Inflow Depth > 2.88" for 100-Year event
Inflow = 55.97 cfs @ 12.22 hrs, Volume= 4.997 af
Outflow = 55.97 cfs @ 12.22 hrs, Volume= 4.997 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: Total



Events for Subcatchment 1S: Area 1

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
2-Year	3.14	0.01	0.006	0.08
10-Year	4.87	0.34	0.043	0.54
25-Year	5.95	0.89	0.077	0.98
100-Year	**7.61**	**1.92**	**0.144**	**1.82**

Events for Subcatchment 2S: Area 2 (undetained)

Event	Rainfall (inches)	Runoff (cfs)	Volume (acre-feet)	Depth (inches)
2-Year	3.14	3.48	0.580	0.35
10-Year	4.87	19.39	1.917	1.16
25-Year	5.95	32.15	2.983	1.80
100-Year	**7.61**	**54.65**	**4.853**	**2.93**

Events for Reach 2R: Total

Event	Inflow (cfs)	Outflow (cfs)	Elevation (feet)	Storage (cubic-feet)
2-Year	3.48	3.48	**0.00**	**0**
10-Year	19.66	19.66	0.00	0
25-Year	32.98	32.98	0.00	0
100-Year	**55.97**	**55.97**	0.00	0

Phineas - Pre-development - Final
Prepared by O'Hara Engineering Svs

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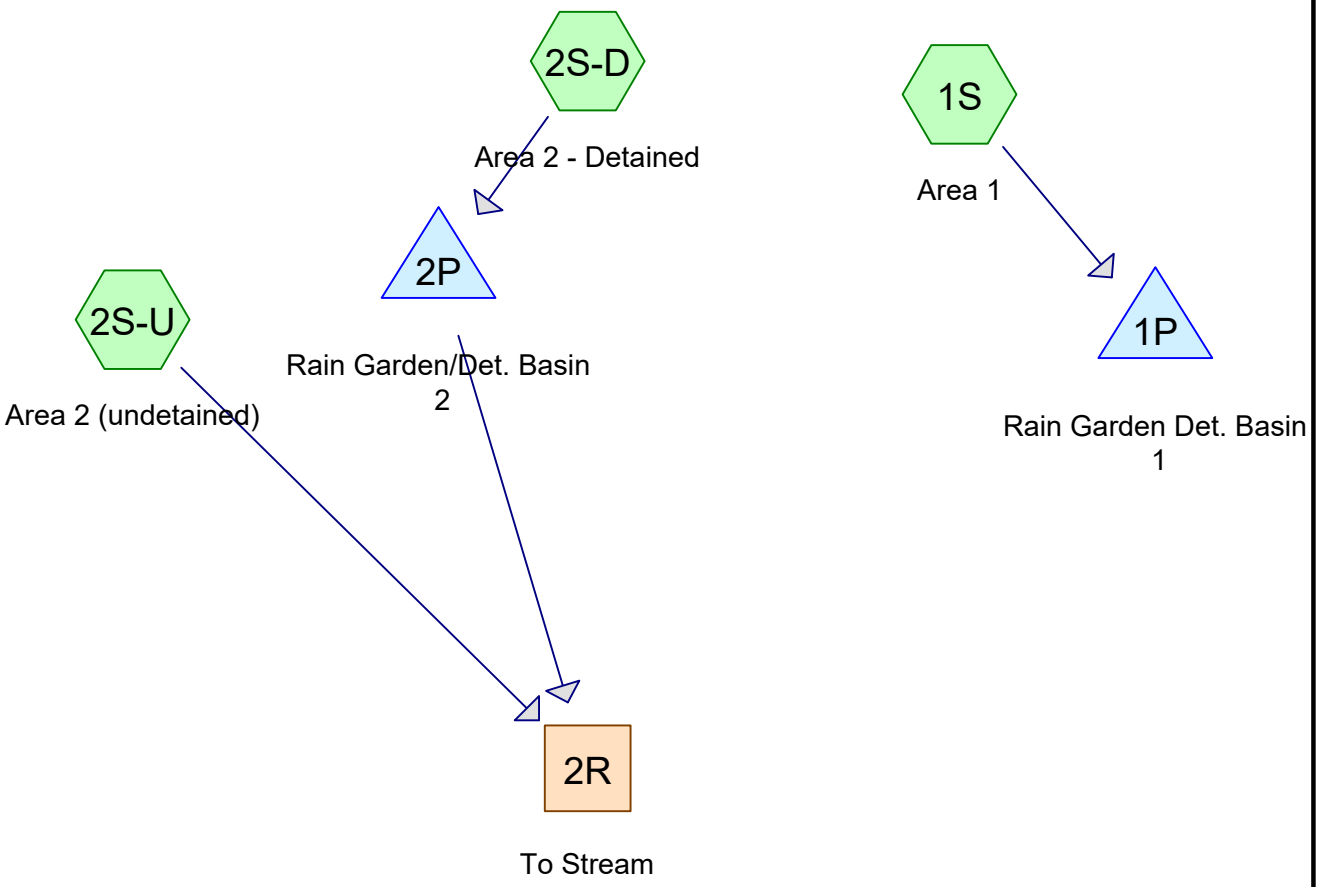


Subcat Reach Pond Link

Routing Diagram for Phineas - Post-Development-final
Prepared by O'Hara Engineering Svs

Project Notes

Rainfall events imported from "NRCS-Rain.txt" for 4079 MA Dracut Middlesex County North
Rainfall events imported from "Phineas - Pre-Development.hcp"

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.900	39	>75% Grass cover, Good, HSG A (2S-U)
0.140	98	Impervious Surfaces (1S)
1.280	98	Impervious surfaces (2S-D)
1.130	39	Open Space - Good cond - A soils (2S-D)
0.630	39	Open Space - good - A soils (1S)
5.420	36	Woods, Fair, HSG A (2S-U)
10.270	77	Woods, Good, HSG D (2S-U)
0.080	43	Woods/grass comb., Fair, HSG A (1S)
20.850	**61**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
7.400	HSG A	1S, 2S-U
0.000	HSG B	
0.000	HSG C	
10.270	HSG D	2S-U
3.180	Other	1S, 2S-D
20.850		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
1.900	0.000	0.000	0.000	0.000	1.900	>75% Grass cover, Good	2S-U
0.000	0.000	0.000	0.000	0.140	0.140	Impervious Surfaces	1S
0.000	0.000	0.000	0.000	1.280	1.280	Impervious surfaces	2S-D
0.000	0.000	0.000	0.000	1.130	1.130	Open Space - Good cond - A soils	2S-D
0.000	0.000	0.000	0.000	0.630	0.630	Open Space - good - A soils	1S
5.420	0.000	0.000	0.000	0.000	5.420	Woods, Fair	2S-U
0.000	0.000	0.000	10.270	0.000	10.270	Woods, Good	2S-U
0.080	0.000	0.000	0.000	0.000	0.080	Woods/grass comb., Fair	1S
7.400	**0.000**	**0.000**	**10.270**	**3.180**	**20.850**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)
1	1S	0.00	0.00	125.0	0.0500	0.015	0.0	12.0	4.0
2	2S-D	0.00	0.00	450.0	0.0500	0.015	0.0	12.0	8.0

Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.850 ac 16.47% Impervious Runoff Depth>0.10"
Flow Length=175' Tc=6.6 min CN=49 Runoff=0.01 cfs 0.007 af

Subcatchment2S-D: Area2 - Detained Runoff Area=2.410 ac 53.11% Impervious Runoff Depth>0.79"
Flow Length=500' Tc=7.8 min CN=70 Runoff=2.04 cfs 0.159 af

Subcatchment2S-U: Area2 (undetained) Runoff Area=17.590 ac 0.00% Impervious Runoff Depth>0.38"
Flow Length=425' Tc=17.6 min CN=60 Runoff=3.30 cfs 0.560 af

Reach2R: To Stream Inflow=3.30 cfs 0.560 af
Outflow=3.30 cfs 0.560 af

Pond1P: Rain Garden Det. Basin1 Peak Elev=100.00' Storage=4 cf Inflow=0.01 cfs 0.007 af
Outflow=0.01 cfs 0.007 af

Pond2P: Rain Garden/Det. Basin2 Peak Elev=92.89' Storage=1,654 cf Inflow=2.04 cfs 0.159 af
Discarded=0.42 cfs 0.158 af Primary=0.00 cfs 0.000 af Outflow=0.42 cfs 0.158 af

Total Runoff Area = 20.850 ac Runoff Volume = 0.726 af Average Runoff Depth = 0.42"
93.19% Pervious = 19.430 ac 6.81% Impervious = 1.420 ac

Summary for Subcatchment 1S: Area 1

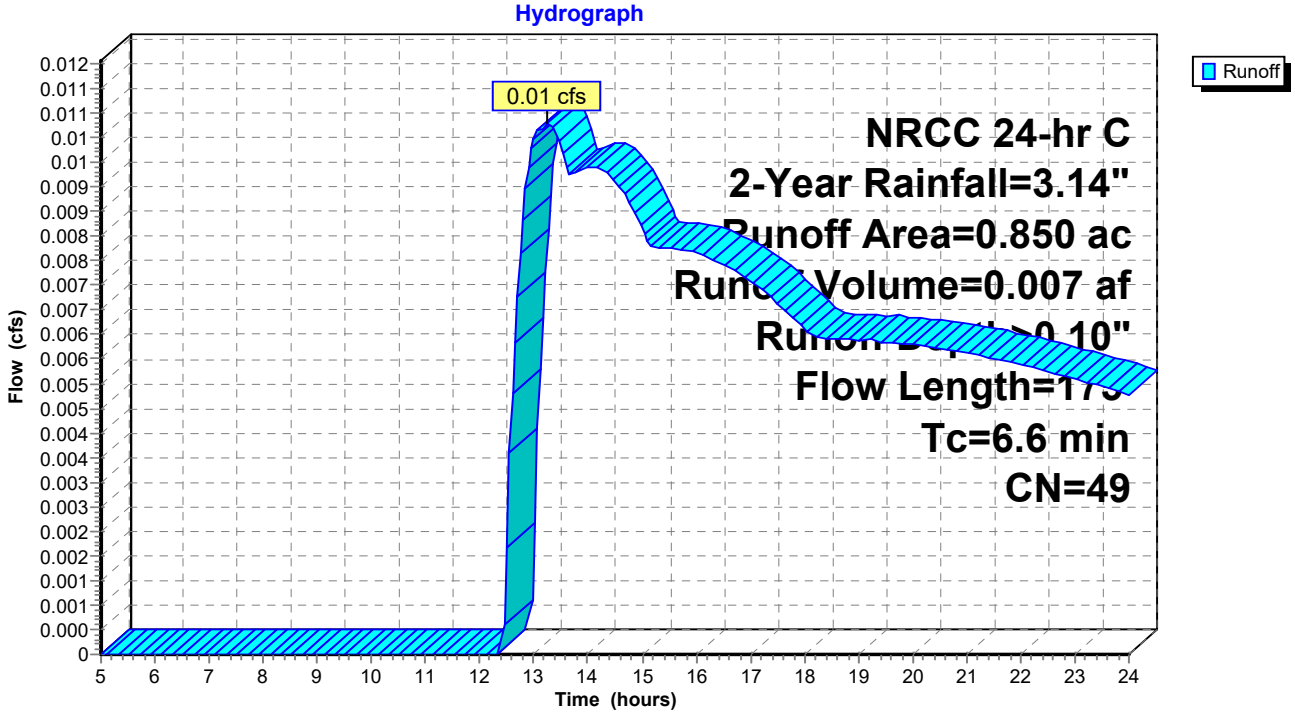
Runoff = 0.01 cfs @ 13.26 hrs, Volume= 0.007 af, Depth> 0.10"
Routed to Pond 1P : Rain Garden Det. Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 2-Year Rainfall=3.14"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.630	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.850	49	Weighted Average
	0.710		83.53% Pervious Area
	0.140		16.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S-D: Area 2 - Detained

[47] Hint: Peak is 180% of capacity of segment #2

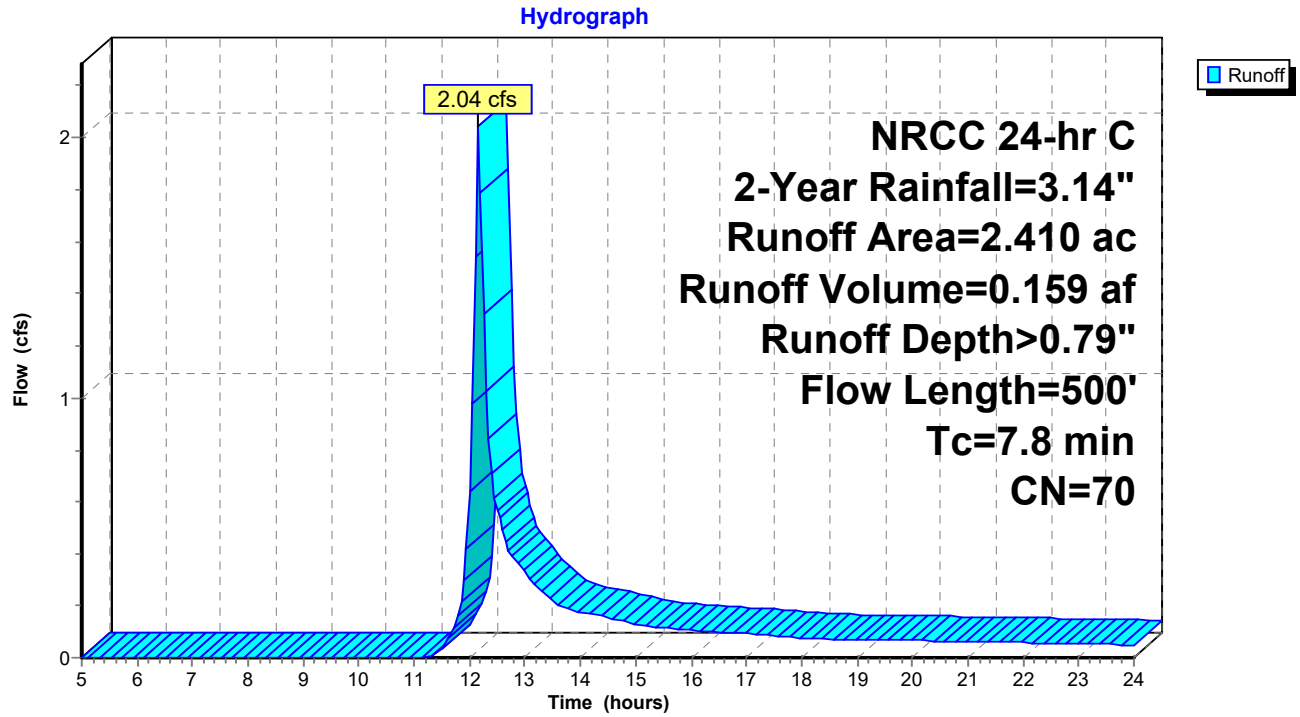
Runoff = 2.04 cfs @ 12.16 hrs, Volume= 0.159 af, Depth> 0.79"
Routed to Pond 2P : Rain Garden/Det. Basin 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 2-Year Rainfall=3.14"

	Area (ac)	CN	Description
*	1.280	98	Impervious surfaces
*	1.130	39	Open Space - Good cond - A soils
	2.410	70	Weighted Average
	1.130		46.89% Pervious Area
	1.280		53.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
1.5	450	0.0500	4.94	1.13	**Pipe Channel, pipe flow** 12.0" Round w/ 8.0" inside fill Area= 0.2 sf Perim= 2.2' r= 0.11' n= 0.015 Concrete sewer w/manholes & inlets
7.8	500	Total			

Subcatchment 2S-D: Area 2 - Detained



Summary for Subcatchment 2S-U: Area 2 (undetained)

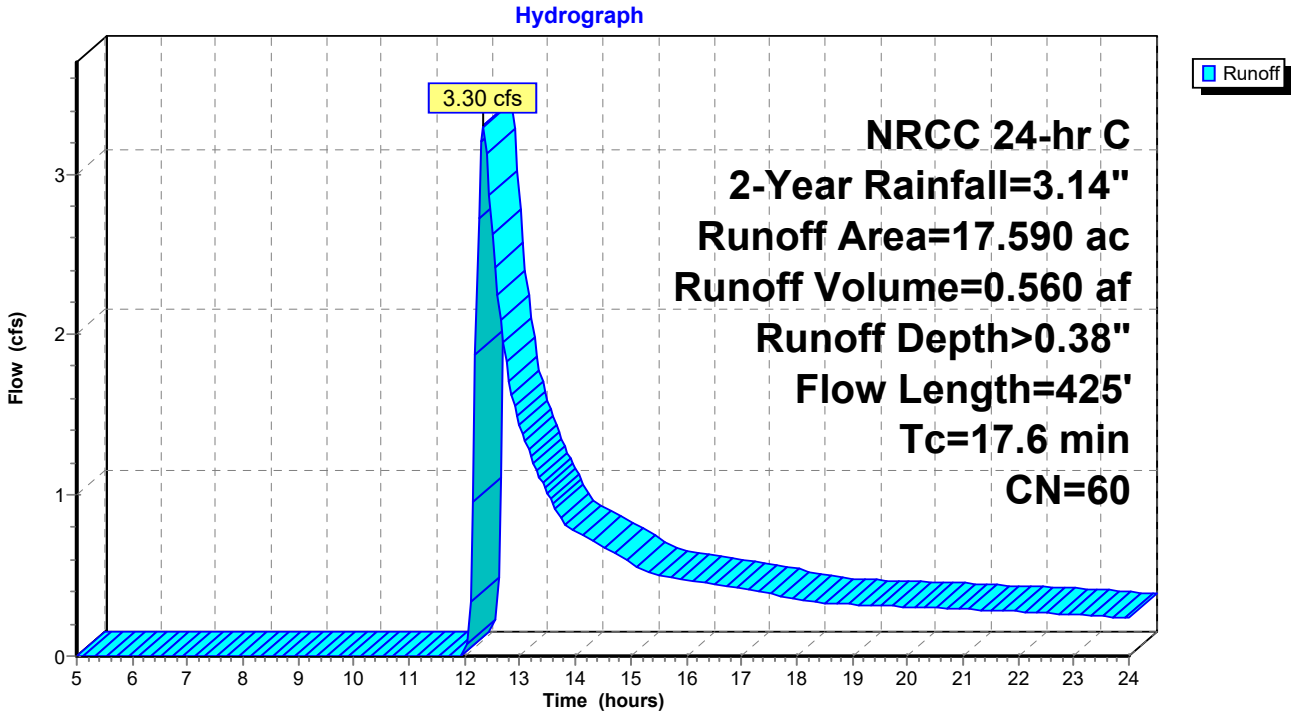
Runoff = 3.30 cfs @ 12.34 hrs, Volume= 0.560 af, Depth> 0.38"
Routed to Reach 2R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 2-Year Rainfall=3.14"

Area (ac)	CN	Description
1.900	39	>75% Grass cover, Good, HSG A
5.420	36	Woods, Fair, HSG A
10.270	77	Woods, Good, HSG D
17.590	60	Weighted Average
17.590		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, sheet flow** Woods: Light underbrush n= 0.400 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
17.6	425	Total			

Subcatchment 2S-U: Area 2 (undetained)



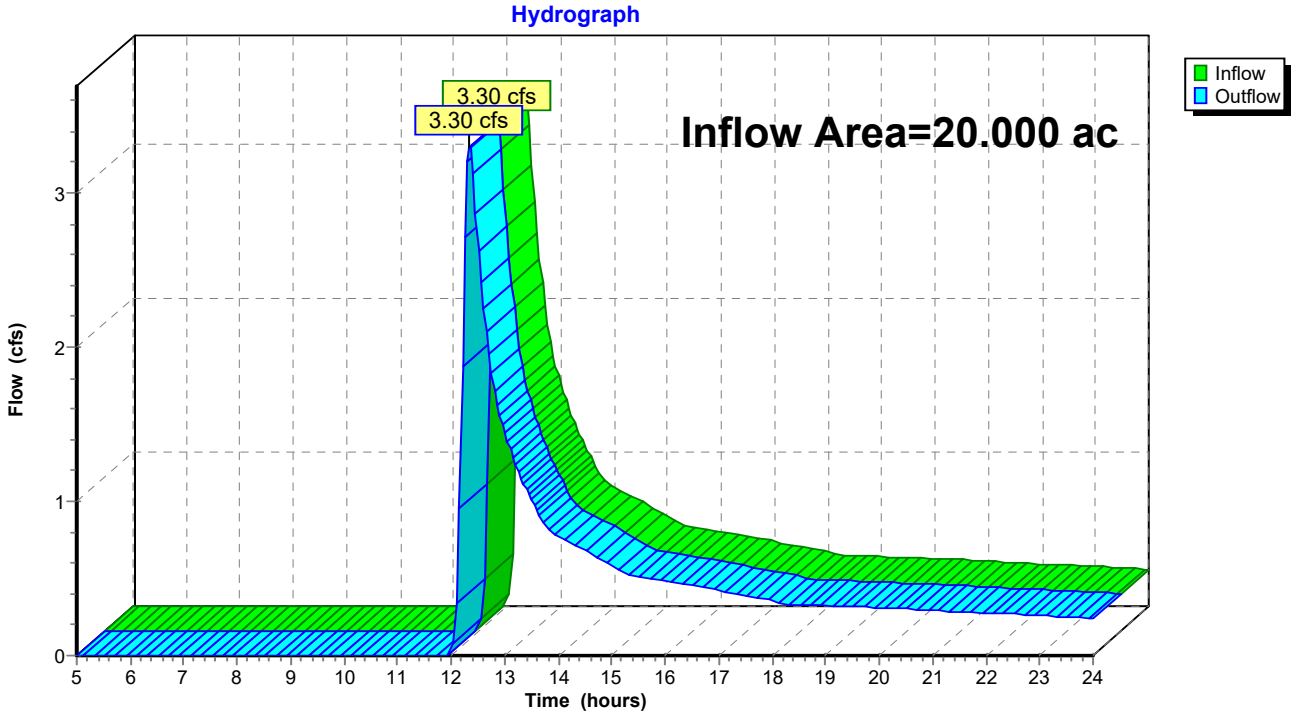
Summary for Reach 2R: To Stream

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

Inflow Area = 20.000 ac, 6.40% Impervious, Inflow Depth > 0.34" for 2-Year event
Inflow = 3.30 cfs @ 12.34 hrs, Volume= 0.560 af
Outflow = 3.30 cfs @ 12.34 hrs, Volume= 0.560 af, Atten= 0%, Lag= 0.0 min
Routed to nonexistent node 10R

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: To Stream



Summary for Pond 1P: Rain Garden Det. Basin 1

Inflow Area = 0.850 ac, 16.47% Impervious, Inflow Depth > 0.10" for 2-Year event
Inflow = 0.01 cfs @ 13.26 hrs, Volume= 0.007 af
Outflow = 0.01 cfs @ 13.36 hrs, Volume= 0.007 af, Atten= 1%, Lag= 6.1 min
Discarded = 0.01 cfs @ 13.36 hrs, Volume= 0.007 af

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.00' @ 13.36 hrs Surf.Area= 979 sf Storage= 4 cf

Plug-Flow detention time=5.7 min calculated for 0.007 af (99% of inflow)
Center-of-Mass det. time=3.4 min (1,061.5 - 1,058.1)

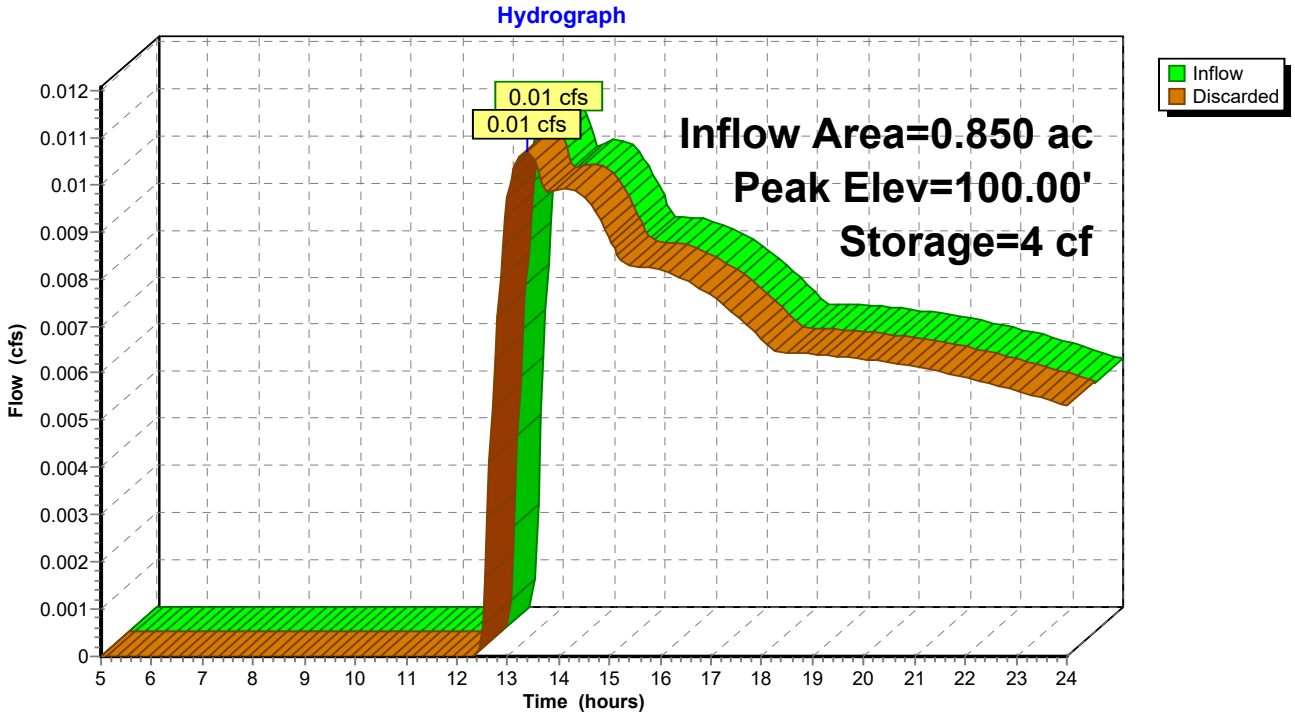
Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	14,444 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	976	0	0
101.00	1,847	1,412	1,412
102.00	2,624	2,236	3,647
103.00	3,266	2,945	6,592
104.00	3,963	3,615	10,207
105.00	4,511	4,237	14,444

Device	Routing	Invert	Outlet Devices
#1	Discarded	100.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 98.00'

Discarded OutFlow Max=0.14 cfs @ 13.36 hrs HW=100.00' (Free Discharge)
↑—**1=Exfiltration** (Controls 0.14 cfs)

Pond 1P: Rain Garden Det. Basin 1



Summary for Pond 2P: Rain Garden/Det. Basin 2

Inflow Area = 2.410 ac, 53.11% Impervious, Inflow Depth > 0.79" for 2-Year event
Inflow = 2.04 cfs @ 12.16 hrs, Volume= 0.159 af
Outflow = 0.42 cfs @ 12.70 hrs, Volume= 0.158 af, Atten= 80%, Lag= 32.5 min
Discarded = 0.42 cfs @ 12.70 hrs, Volume= 0.158 af
Primary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Routed to Reach 2R : To Stream

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 92.89' @ 12.70 hrs Surf.Area= 2,207 sf Storage= 1,654 cf

Plug-Flow detention time=34.4 min calculated for 0.158 af (100% of inflow)
Center-of-Mass det. time=32.8 min (924.6 - 891.9)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	31,979 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

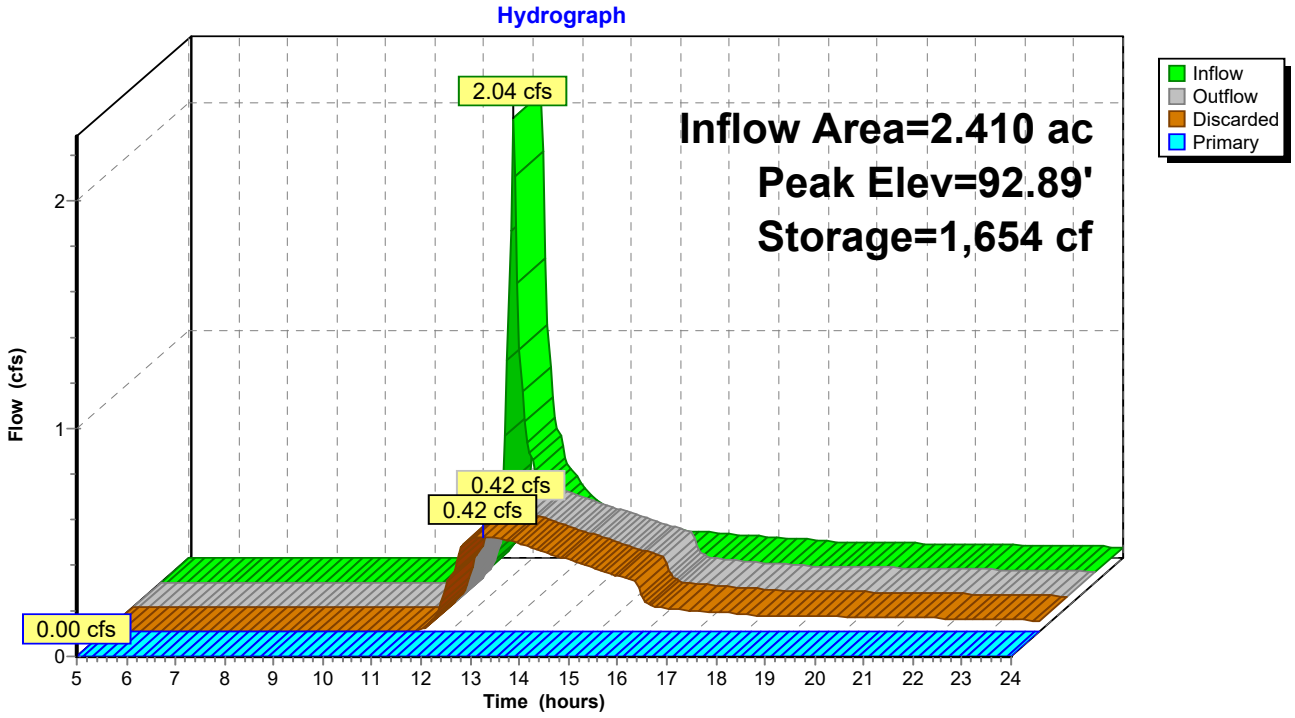
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
92.00	1,515	0	0
93.00	2,293	1,904	1,904
94.00	3,344	2,819	4,723
95.00	4,907	4,126	8,848
96.00	6,380	5,644	14,492
97.00	7,894	7,137	21,629
98.00	12,807	10,351	31,979

Device	Routing	Invert	Outlet Devices
#1	Primary	94.50'	**6.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	95.50'	**12.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	97.00'	**1.5" x 1.5" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#4	Discarded	92.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 90.00'

Discarded OutFlow Max=0.42 cfs @ 12.70 hrs HW=92.89' (Free Discharge)
└**4=Exfiltration** (Controls 0.42 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=92.00' (Free Discharge)
└**1=Orifice/Grate** (Controls 0.00 cfs)
└**2=Orifice/Grate** (Controls 0.00 cfs)
└**3=Orifice/Grate** (Controls 0.00 cfs)

Pond 2P: Rain Garden/Det. Basin 2



Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.850 ac 16.47% Impervious Runoff Depth>0.59"
Flow Length=175' Tc=6.6 min CN=49 Runoff=0.37 cfs 0.042 af

Subcatchment2S-D: Area2 - Detained Runoff Area=2.410 ac 53.11% Impervious Runoff Depth>1.94"
Flow Length=500' Tc=7.8 min CN=70 Runoff=5.38 cfs 0.389 af

Subcatchment2S-U: Area2 (undetained) Runoff Area=17.590 ac 0.00% Impervious Runoff Depth>1.22"
Flow Length=425' Tc=17.6 min CN=60 Runoff=16.24 cfs 1.786 af

Reach2R: To Stream Inflow=16.24 cfs 1.786 af
Outflow=16.24 cfs 1.786 af

Pond1P: Rain Garden Det. Basin1 Peak Elev=100.14' Storage=142 cf Inflow=0.37 cfs 0.042 af
Outflow=0.16 cfs 0.041 af

Pond2P: Rain Garden/Det. Basin2 Peak Elev=94.22' Storage=5,503 cf Inflow=5.38 cfs 0.389 af
Discarded=0.85 cfs 0.388 af Primary=0.00 cfs 0.000 af Outflow=0.85 cfs 0.388 af

Total Runoff Area = 20.850 ac Runoff Volume = 2.216 af Average Runoff Depth = 1.28"
93.19% Pervious = 19.430 ac 6.81% Impervious = 1.420 ac

Summary for Subcatchment 1S: Area 1

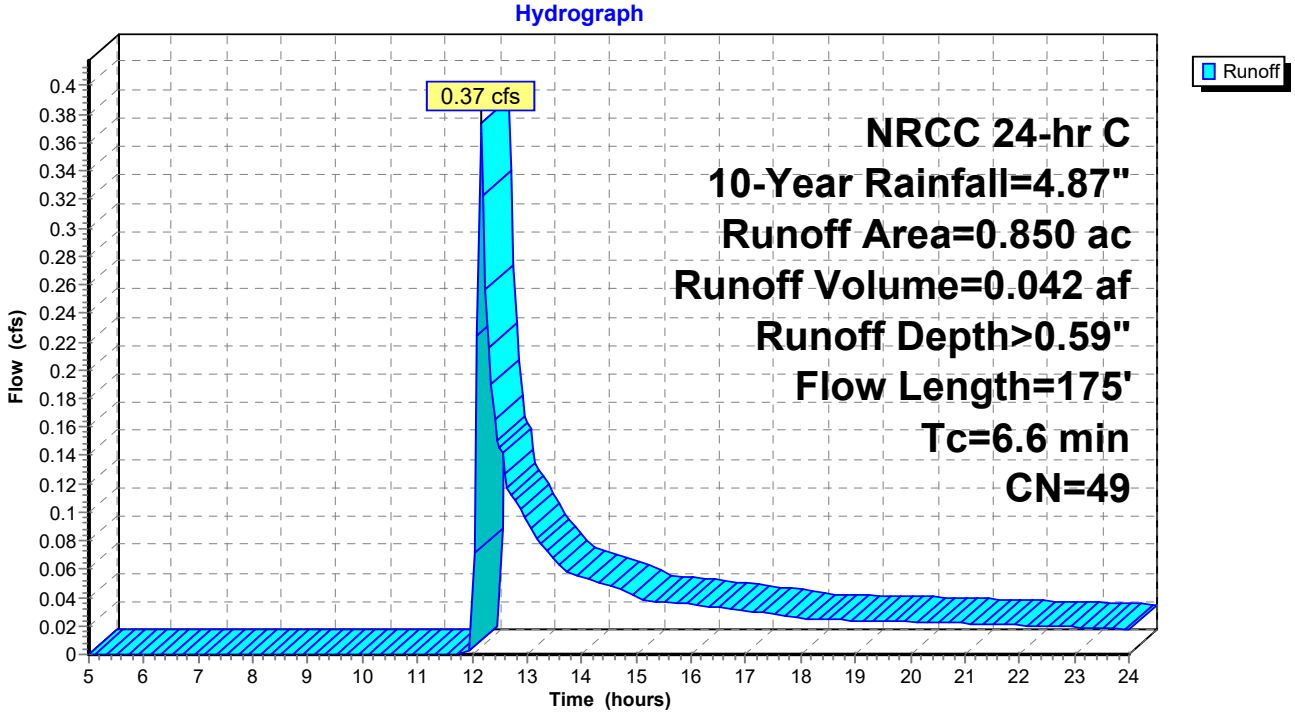
Runoff = 0.37 cfs @ 12.16 hrs, Volume= 0.042 af, Depth> 0.59"
Routed to Pond 1P : Rain Garden Det. Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 10-Year Rainfall=4.87"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.630	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.850	49	Weighted Average
	0.710		83.53% Pervious Area
	0.140		16.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S-D: Area 2 - Detained

[47] Hint: Peak is 475% of capacity of segment #2

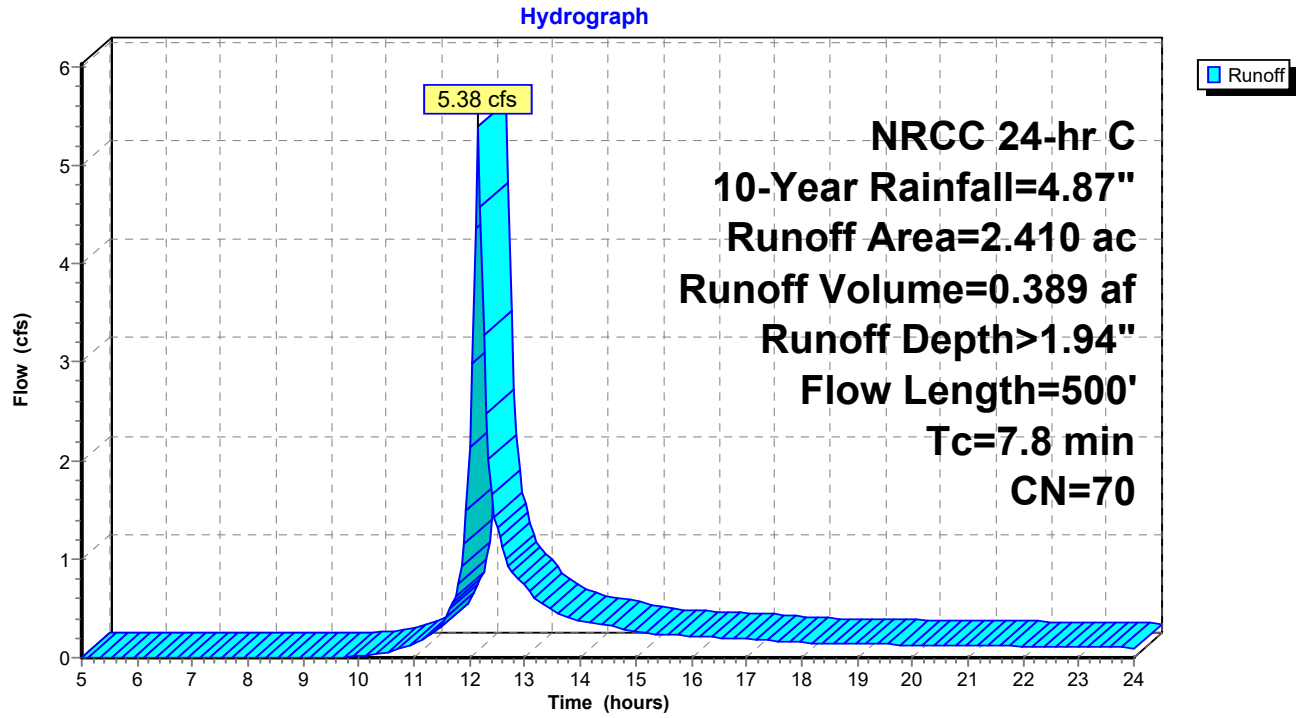
Runoff = 5.38 cfs @ 12.15 hrs, Volume= 0.389 af, Depth> 1.94"
Routed to Pond 2P : Rain Garden/Det. Basin 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 10-Year Rainfall=4.87"

	Area (ac)	CN	Description
*	1.280	98	Impervious surfaces
*	1.130	39	Open Space - Good cond - A soils
	2.410	70	Weighted Average
	1.130		46.89% Pervious Area
	1.280		53.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
1.5	450	0.0500	4.94	1.13	**Pipe Channel, pipe flow** 12.0" Round w/ 8.0" inside fill Area= 0.2 sf Perim= 2.2' r= 0.11' n= 0.015 Concrete sewer w/manholes & inlets
7.8	500	Total			

Subcatchment 2S-D: Area 2 - Detained



Summary for Subcatchment 2S-U: Area 2 (undetained)

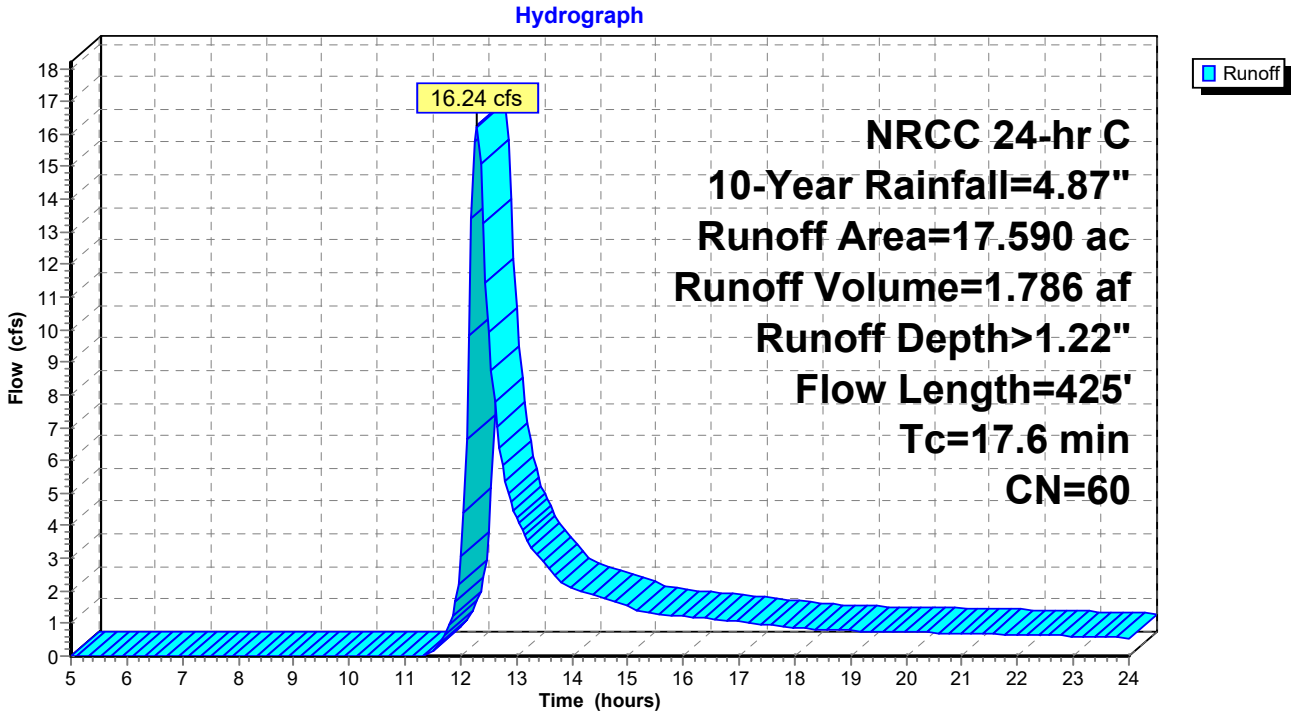
Runoff = 16.24 cfs @ 12.29 hrs, Volume= 1.786 af, Depth> 1.22"
Routed to Reach 2R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 10-Year Rainfall=4.87"

Area (ac)	CN	Description
1.900	39	>75% Grass cover, Good, HSG A
5.420	36	Woods, Fair, HSG A
10.270	77	Woods, Good, HSG D
17.590	60	Weighted Average
17.590		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, sheet flow** Woods: Light underbrush n= 0.400 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
17.6	425	Total			

Subcatchment 2S-U: Area 2 (undetained)



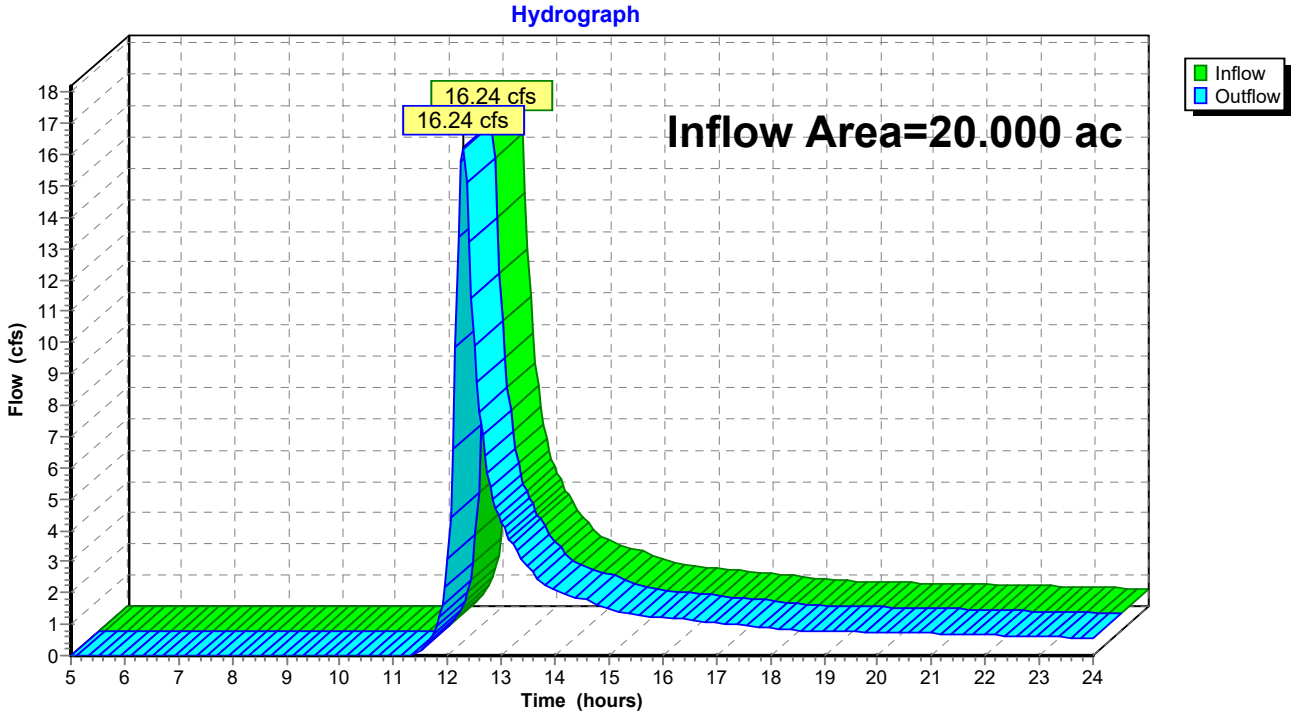
Summary for Reach 2R: To Stream

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

Inflow Area = 20.000 ac, 6.40% Impervious, Inflow Depth > 1.07" for 10-Year event
Inflow = 16.24 cfs @ 12.29 hrs, Volume= 1.786 af
Outflow = 16.24 cfs @ 12.29 hrs, Volume= 1.786 af, Atten= 0%, Lag= 0.0 min
Routed to nonexistent node 10R

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: To Stream



Summary for Pond 1P: Rain Garden Det. Basin 1

Inflow Area = 0.850 ac, 16.47% Impervious, Inflow Depth > 0.59" for 10-Year event
Inflow = 0.37 cfs @ 12.16 hrs, Volume= 0.042 af
Outflow = 0.16 cfs @ 12.42 hrs, Volume= 0.041 af, Atten= 57%, Lag= 15.1 min
Discarded = 0.16 cfs @ 12.42 hrs, Volume= 0.041 af

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.14' @ 12.42 hrs Surf.Area= 1,096 sf Storage= 142 cf

Plug-Flow detention time=7.4 min calculated for 0.041 af (99% of inflow)
Center-of-Mass det. time=5.8 min (947.4 - 941.6)

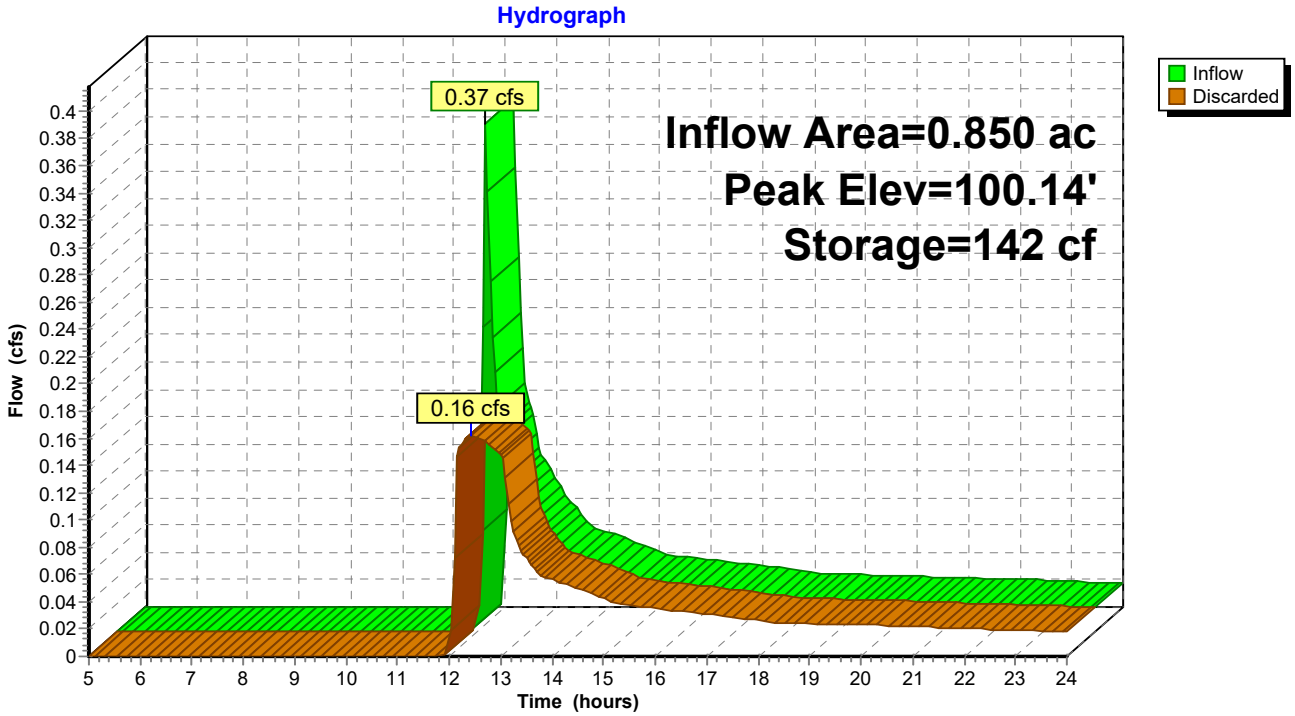
Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	14,444 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	976	0	0
101.00	1,847	1,412	1,412
102.00	2,624	2,236	3,647
103.00	3,266	2,945	6,592
104.00	3,963	3,615	10,207
105.00	4,511	4,237	14,444

Device	Routing	Invert	Outlet Devices
#1	Discarded	100.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 98.00'

Discarded OutFlow Max=0.16 cfs @ 12.42 hrs HW=100.14' (Free Discharge)
↑—**1=Exfiltration** (Controls 0.16 cfs)

Pond 1P: Rain Garden Det. Basin 1



Summary for Pond 2P: Rain Garden/Det. Basin 2

Inflow Area = 2.410 ac, 53.11% Impervious, Inflow Depth > 1.94" for 10-Year event
Inflow = 5.38 cfs @ 12.15 hrs, Volume= 0.389 af
Outflow = 0.85 cfs @ 12.80 hrs, Volume= 0.388 af, Atten= 84%, Lag= 38.9 min
Discarded = 0.85 cfs @ 12.80 hrs, Volume= 0.388 af
Primary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
Routed to Reach 2R : To Stream

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 94.22' @ 12.80 hrs Surf.Area= 3,691 sf Storage= 5,503 cf

Plug-Flow detention time=70.1 min calculated for 0.387 af (99% of inflow)
Center-of-Mass det. time=68.5 min (929.9 - 861.4)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	31,979 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

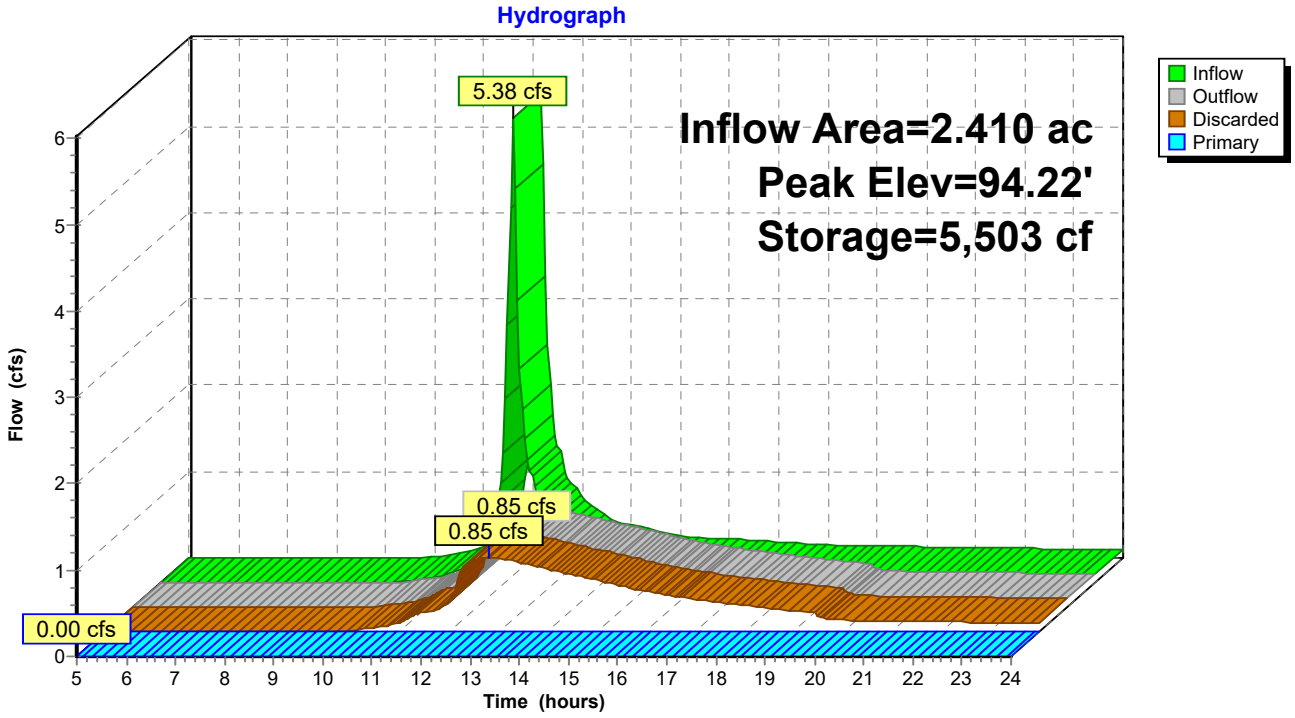
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
92.00	1,515	0	0
93.00	2,293	1,904	1,904
94.00	3,344	2,819	4,723
95.00	4,907	4,126	8,848
96.00	6,380	5,644	14,492
97.00	7,894	7,137	21,629
98.00	12,807	10,351	31,979

Device	Routing	Invert	Outlet Devices
#1	Primary	94.50'	**6.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	95.50'	**12.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	97.00'	**1.5" x 1.5" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#4	Discarded	92.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 90.00'

Discarded OutFlow Max=0.85 cfs @ 12.80 hrs HW=94.22' (Free Discharge)
└**4=Exfiltration** (Controls 0.85 cfs)

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=92.00' (Free Discharge)
└**1=Orifice/Grate** (Controls 0.00 cfs)
└**2=Orifice/Grate** (Controls 0.00 cfs)
└**3=Orifice/Grate** (Controls 0.00 cfs)

Pond 2P: Rain Garden/Det. Basin 2



Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.850 ac 16.47% Impervious Runoff Depth>1.05"
Flow Length=175' Tc=6.6 min CN=49 Runoff=0.88 cfs 0.074 af

Subcatchment2S-D: Area2 - Detained Runoff Area=2.410 ac 53.11% Impervious Runoff Depth>2.76"
Flow Length=500' Tc=7.8 min CN=70 Runoff=7.73 cfs 0.554 af

Subcatchment2S-U: Area2 (undetained) Runoff Area=17.590 ac 0.00% Impervious Runoff Depth>1.88"
Flow Length=425' Tc=17.6 min CN=60 Runoff=26.52 cfs 2.753 af

Reach2R: To Stream Inflow=26.55 cfs 2.774 af
Outflow=26.55 cfs 2.774 af

Pond1P: Rain Garden Det. Basin1 Peak Elev=100.46' Storage=543 cf Inflow=0.88 cfs 0.074 af
Outflow=0.23 cfs 0.074 af

Pond2P: Rain Garden/Det. Basin2 Peak Elev=94.85' Storage=8,139 cf Inflow=7.73 cfs 0.554 af
Discarded=1.12 cfs 0.533 af Primary=0.30 cfs 0.020 af Outflow=1.42 cfs 0.553 af

Total Runoff Area = 20.850 ac Runoff Volume = 3.382 af Average Runoff Depth = 1.95"
93.19% Pervious = 19.430 ac 6.81% Impervious = 1.420 ac

Summary for Subcatchment 1S: Area 1

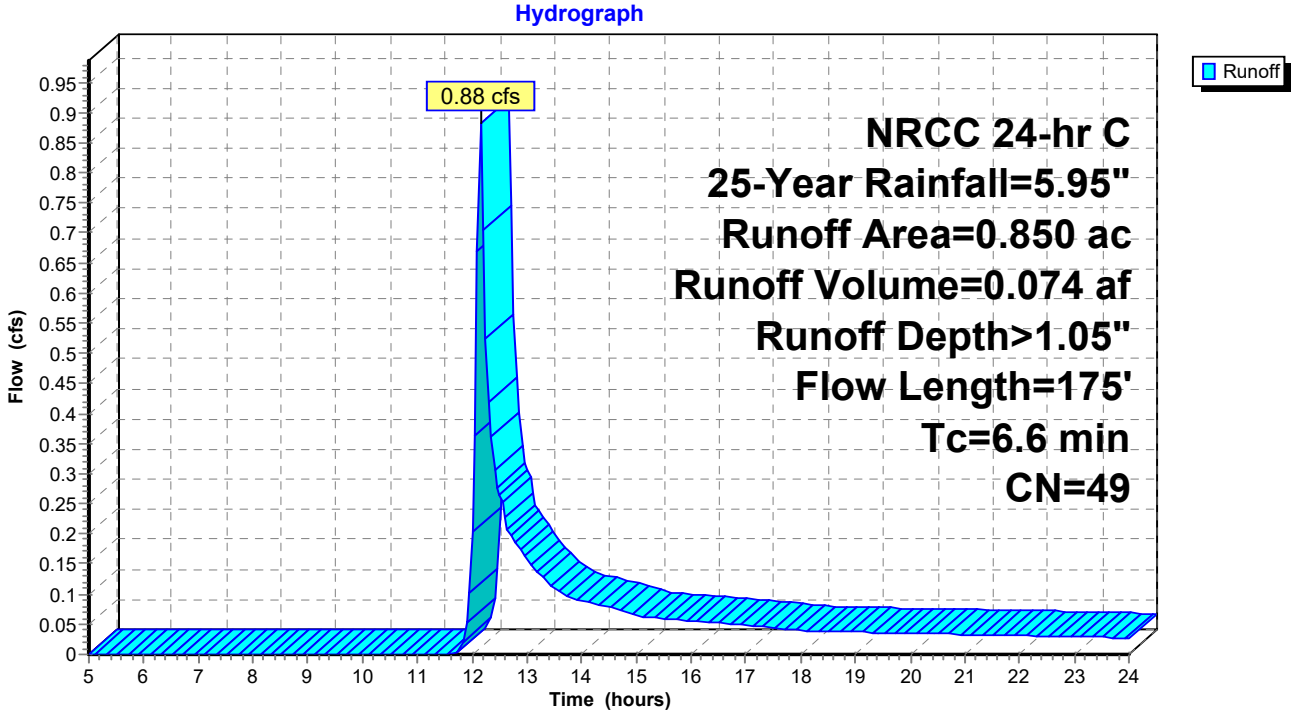
Runoff = 0.88 cfs @ 12.15 hrs, Volume= 0.074 af, Depth> 1.05"
Routed to Pond 1P : Rain Garden Det. Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 25-Year Rainfall=5.95"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.630	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.850	49	Weighted Average
	0.710		83.53% Pervious Area
	0.140		16.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S-D: Area 2 - Detained

[47] Hint: Peak is 683% of capacity of segment #2

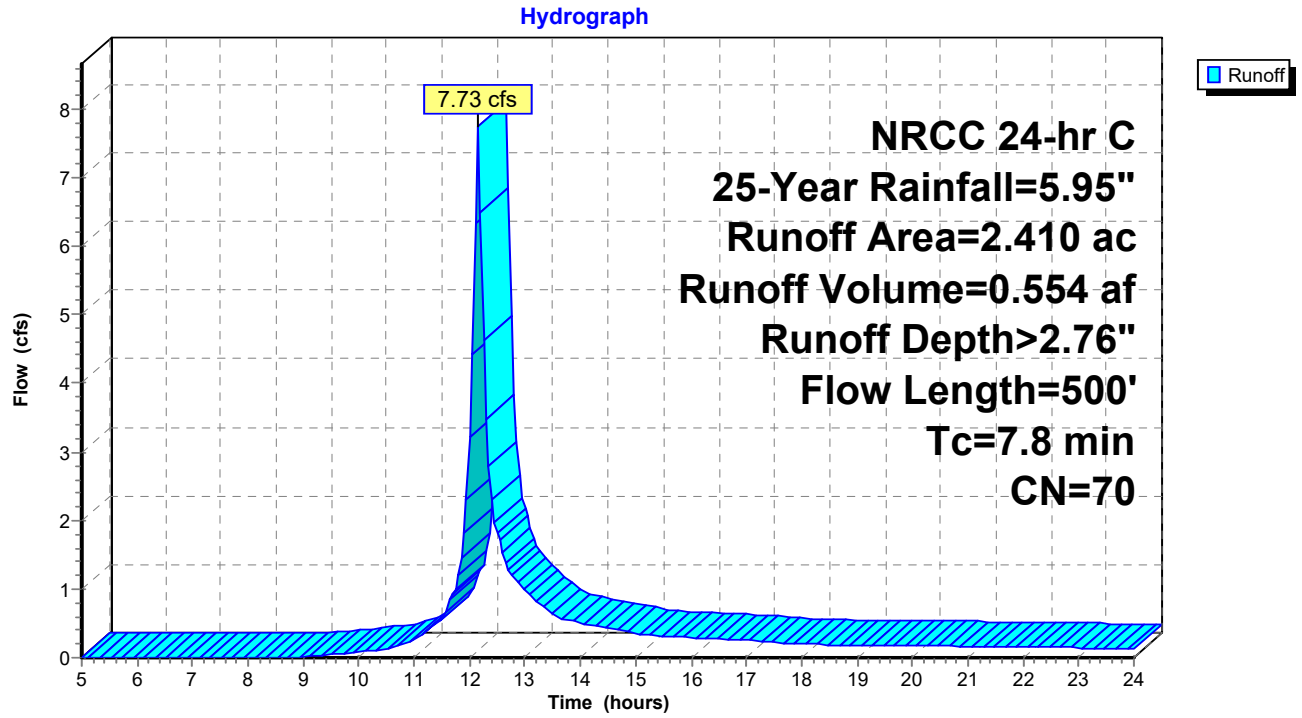
Runoff = 7.73 cfs @ 12.15 hrs, Volume= 0.554 af, Depth> 2.76"
Routed to Pond 2P : Rain Garden/Det. Basin 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 25-Year Rainfall=5.95"

	Area (ac)	CN	Description
*	1.280	98	Impervious surfaces
*	1.130	39	Open Space - Good cond - A soils
	2.410	70	Weighted Average
	1.130		46.89% Pervious Area
	1.280		53.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
1.5	450	0.0500	4.94	1.13	**Pipe Channel, pipe flow** 12.0" Round w/ 8.0" inside fill Area= 0.2 sf Perim= 2.2' r= 0.11' n= 0.015 Concrete sewer w/manholes & inlets
7.8	500	Total			

Subcatchment 2S-D: Area 2 - Detained



Summary for Subcatchment 2S-U: Area 2 (undetained)

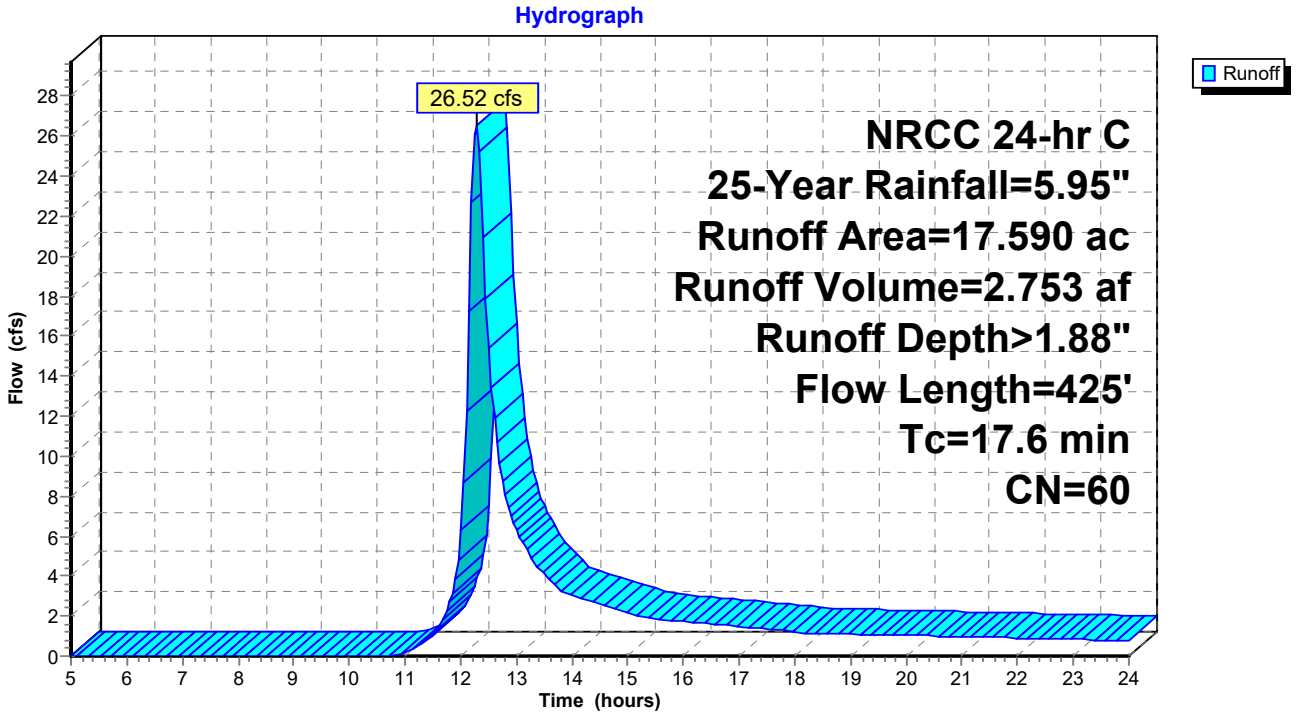
Runoff = 26.52 cfs @ 12.28 hrs, Volume= 2.753 af, Depth> 1.88"
Routed to Reach 2R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 25-Year Rainfall=5.95"

Area (ac)	CN	Description
1.900	39	>75% Grass cover, Good, HSG A
5.420	36	Woods, Fair, HSG A
10.270	77	Woods, Good, HSG D
17.590	60	Weighted Average
17.590		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, sheet flow** Woods: Light underbrush n= 0.400 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
17.6	425	Total			

Subcatchment 2S-U: Area 2 (undetained)



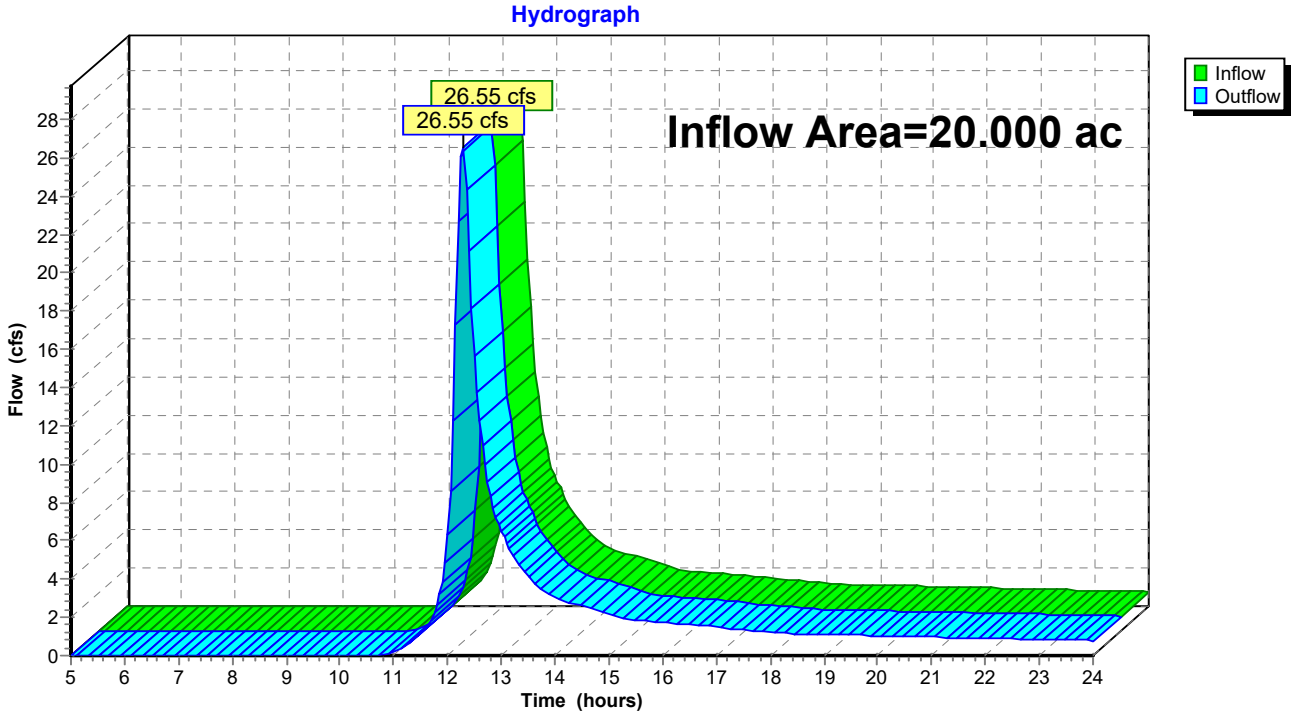
Summary for Reach 2R: To Stream

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

Inflow Area = 20.000 ac, 6.40% Impervious, Inflow Depth > 1.66" for 25-Year event
Inflow = 26.55 cfs @ 12.28 hrs, Volume= 2.774 af
Outflow = 26.55 cfs @ 12.28 hrs, Volume= 2.774 af, Atten= 0%, Lag= 0.0 min
Routed to nonexistent node 10R

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: To Stream



Summary for Pond 1P: Rain Garden Det. Basin 1

Inflow Area = 0.850 ac, 16.47% Impervious, Inflow Depth > 1.05" for 25-Year event
Inflow = 0.88 cfs @ 12.15 hrs, Volume= 0.074 af
Outflow = 0.23 cfs @ 12.60 hrs, Volume= 0.074 af, Atten= 74%, Lag= 26.9 min
Discarded = 0.23 cfs @ 12.60 hrs, Volume= 0.074 af

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 100.46' @ 12.60 hrs Surf.Area= 1,378 sf Storage= 543 cf

Plug-Flow detention time= 18.4 min calculated for 0.074 af (100% of inflow)
Center-of-Mass det. time= 16.9 min (931.9 - 915.0)

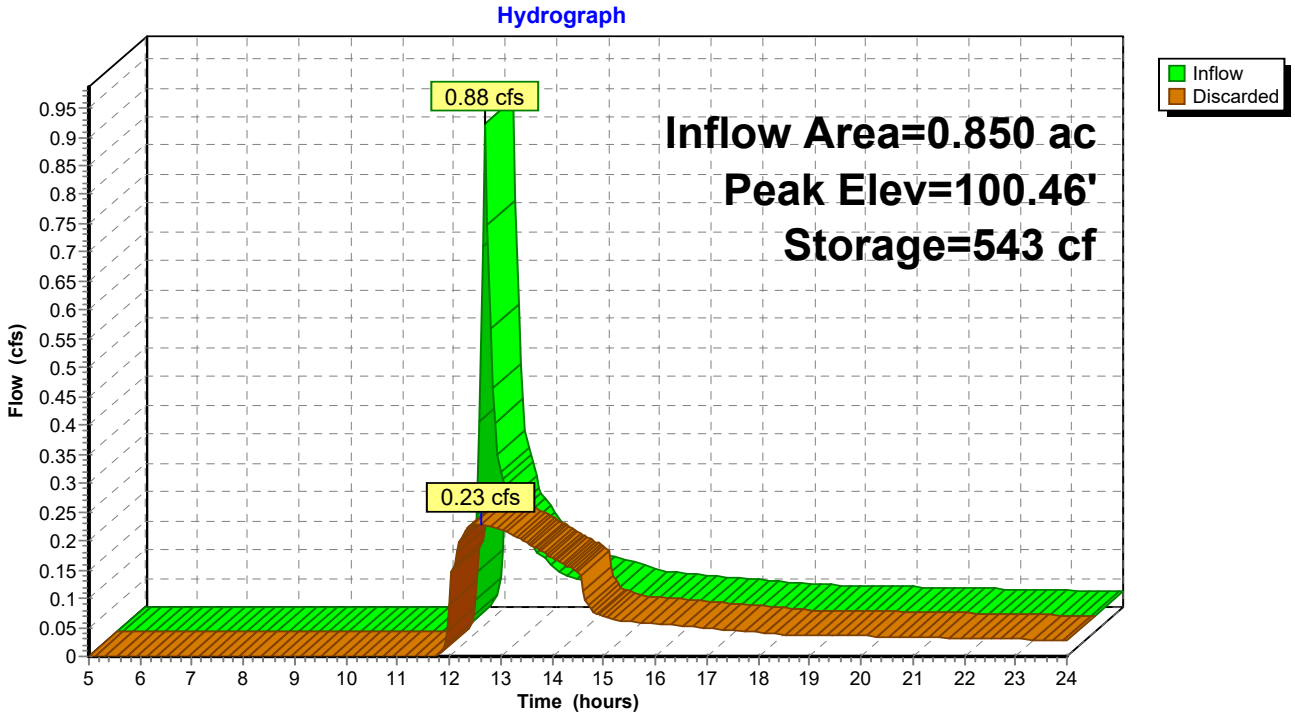
Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	14,444 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	976	0	0
101.00	1,847	1,412	1,412
102.00	2,624	2,236	3,647
103.00	3,266	2,945	6,592
104.00	3,963	3,615	10,207
105.00	4,511	4,237	14,444

Device	Routing	Invert	Outlet Devices
#1	Discarded	100.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 98.00'

Discarded OutFlow Max=0.23 cfs @ 12.60 hrs HW=100.46' (Free Discharge)
↑—**1=Exfiltration** (Controls 0.23 cfs)

Pond 1P: Rain Garden Det. Basin 1



Summary for Pond 2P: Rain Garden/Det. Basin 2

Inflow Area = 2.410 ac, 53.11% Impervious, Inflow Depth > 2.76" for 25-Year event
Inflow = 7.73 cfs @ 12.15 hrs, Volume= 0.554 af
Outflow = 1.42 cfs @ 12.64 hrs, Volume= 0.553 af, Atten= 82%, Lag= 29.2 min
Discarded = 1.12 cfs @ 12.64 hrs, Volume= 0.533 af
Primary = 0.30 cfs @ 12.64 hrs, Volume= 0.020 af
Routed to Reach 2R : To Stream

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 94.85' @ 12.64 hrs Surf.Area= 4,676 sf Storage= 8,139 cf

Plug-Flow detention time=79.0 min calculated for 0.553 af (100% of inflow)
Center-of-Mass det. time=77.7 min (927.7 - 850.0)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	31,979 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

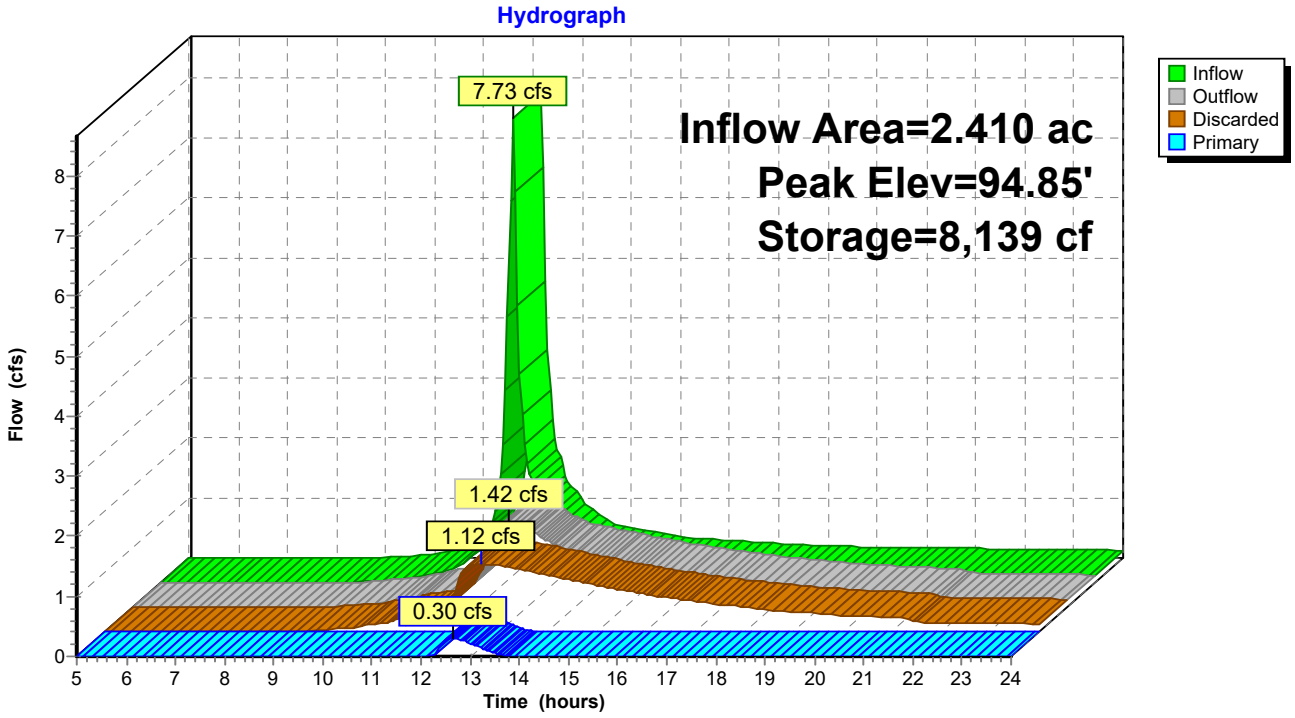
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
92.00	1,515	0	0
93.00	2,293	1,904	1,904
94.00	3,344	2,819	4,723
95.00	4,907	4,126	8,848
96.00	6,380	5,644	14,492
97.00	7,894	7,137	21,629
98.00	12,807	10,351	31,979

Device	Routing	Invert	Outlet Devices
#1	Primary	94.50'	**6.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	95.50'	**12.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	97.00'	**1.5" x 1.5" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#4	Discarded	92.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 90.00'

Discarded OutFlow Max=1.12 cfs @ 12.64 hrs HW=94.85' (Free Discharge)
└**4=Exfiltration** (Controls 1.12 cfs)

Primary OutFlow Max=0.30 cfs @ 12.64 hrs HW=94.85' (Free Discharge)
├**1=Orifice/Grate** (Orifice Controls 0.30 cfs @ 2.02 fps)
├**2=Orifice/Grate** (Controls 0.00 cfs)
└**3=Orifice/Grate** (Controls 0.00 cfs)

Pond 2P: Rain Garden/Det. Basin 2



Time span=5.00-24.00 hrs, dt=0.05 hrs, 381 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Area1 Runoff Area=0.850 ac 16.47% Impervious Runoff Depth>1.91"
Flow Length=175' Tc=6.6 min CN=49 Runoff=1.84 cfs 0.136 af

Subcatchment2S-D: Area2 - Detained Runoff Area=2.410 ac 53.11% Impervious Runoff Depth>4.12"
Flow Length=500' Tc=7.8 min CN=70 Runoff=11.55 cfs 0.828 af

Subcatchment2S-U: Area2 (undetained) Runoff Area=17.590 ac 0.00% Impervious Runoff Depth>3.03"
Flow Length=425' Tc=17.6 min CN=60 Runoff=44.45 cfs 4.439 af

Reach2R: To Stream Inflow=45.23 cfs 4.554 af
Outflow=45.23 cfs 4.554 af

Pond1P: Rain Garden Det. Basin1 Peak Elev=101.02' Storage=1,444 cf Inflow=1.84 cfs 0.136 af
Outflow=0.35 cfs 0.135 af

Pond2P: Rain Garden/Det. Basin2 Peak Elev=95.63' Storage=12,233 cf Inflow=11.55 cfs 0.828 af
Discarded=1.48 cfs 0.711 af Primary=0.96 cfs 0.115 af Outflow=2.44 cfs 0.826 af

Total Runoff Area = 20.850 ac Runoff Volume = 5.403 af Average Runoff Depth = 3.11"
93.19% Pervious = 19.430 ac 6.81% Impervious = 1.420 ac

Summary for Subcatchment 1S: Area 1

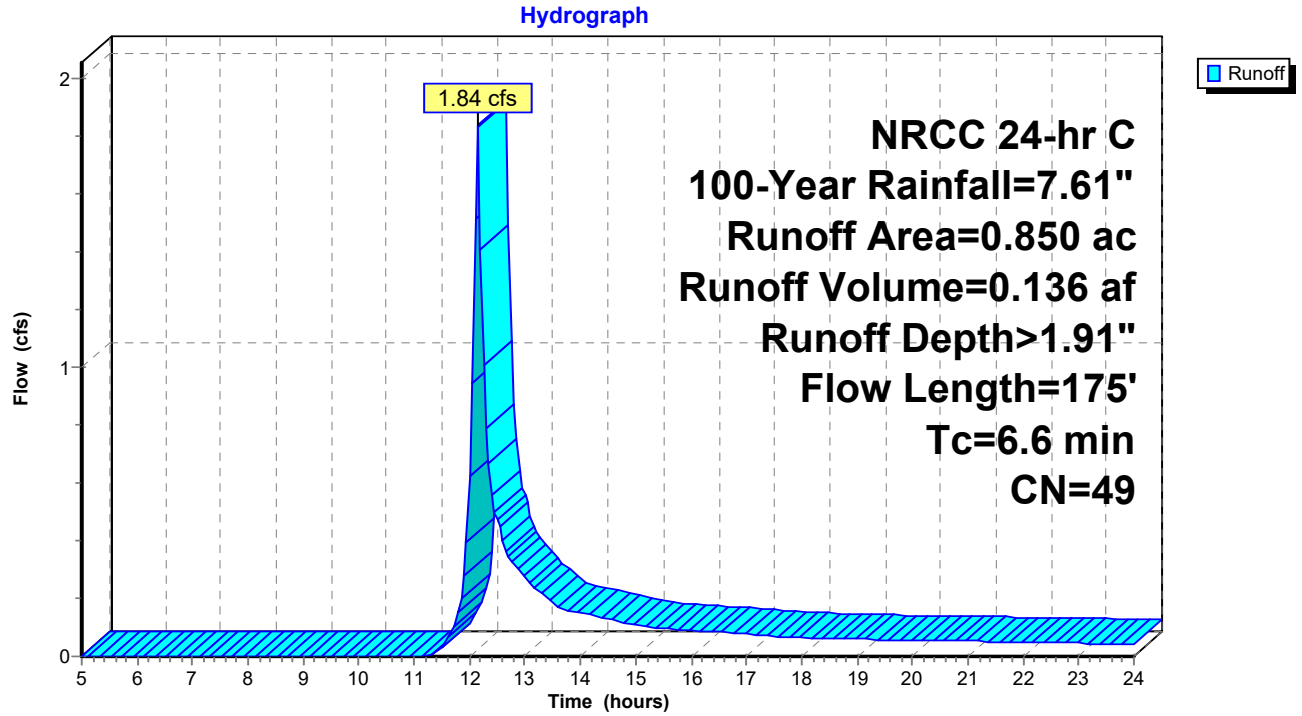
Runoff = 1.84 cfs @ 12.15 hrs, Volume= 0.136 af, Depth> 1.91"
Routed to Pond 1P : Rain Garden Det. Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 100-Year Rainfall=7.61"

	Area (ac)	CN	Description
*	0.140	98	Impervious Surfaces
*	0.630	39	Open Space - good - A soils
	0.080	43	Woods/grass comb., Fair, HSG A
	0.850	49	Weighted Average
	0.710		83.53% Pervious Area
	0.140		16.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, sheet flow - lawns** Grass: Dense n= 0.240 P2= 3.14"
0.3	125	0.0500	7.45	4.14	**Pipe Channel, pipe flow** 12.0" Round w/ 4.0" inside fill Area= 0.6 sf Perim= 2.9' r= 0.19' n= 0.015 Concrete sewer w/manholes & inlets
6.6	175	Total			

Subcatchment 1S: Area 1



Summary for Subcatchment 2S-D: Area 2 - Detained

[47] Hint: Peak is 1019% of capacity of segment #2

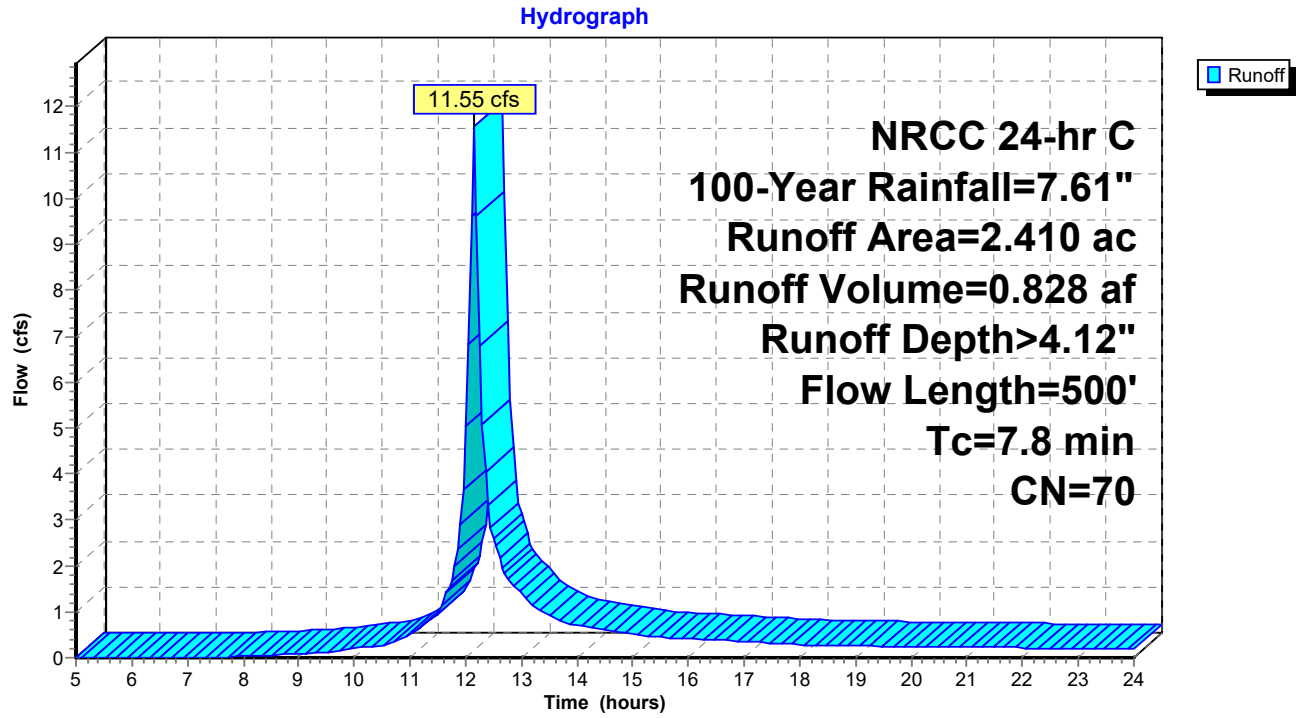
Runoff = 11.55 cfs @ 12.15 hrs, Volume= 0.828 af, Depth> 4.12"
Routed to Pond 2P : Rain Garden/Det. Basin 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 100-Year Rainfall=7.61"

	Area (ac)	CN	Description
*	1.280	98	Impervious surfaces
*	1.130	39	Open Space - Good cond - A soils
	2.410	70	Weighted Average
	1.130		46.89% Pervious Area
	1.280		53.11% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	50	0.0400	0.13		**Sheet Flow, lawns** Grass: Dense n= 0.240 P2= 3.14"
1.5	450	0.0500	4.94	1.13	**Pipe Channel, pipe flow** 12.0" Round w/ 8.0" inside fill Area= 0.2 sf Perim= 2.2' r= 0.11' n= 0.015 Concrete sewer w/manholes & inlets
7.8	500	Total			

Subcatchment 2S-D: Area 2 - Detained



Summary for Subcatchment 2S-U: Area 2 (undetained)

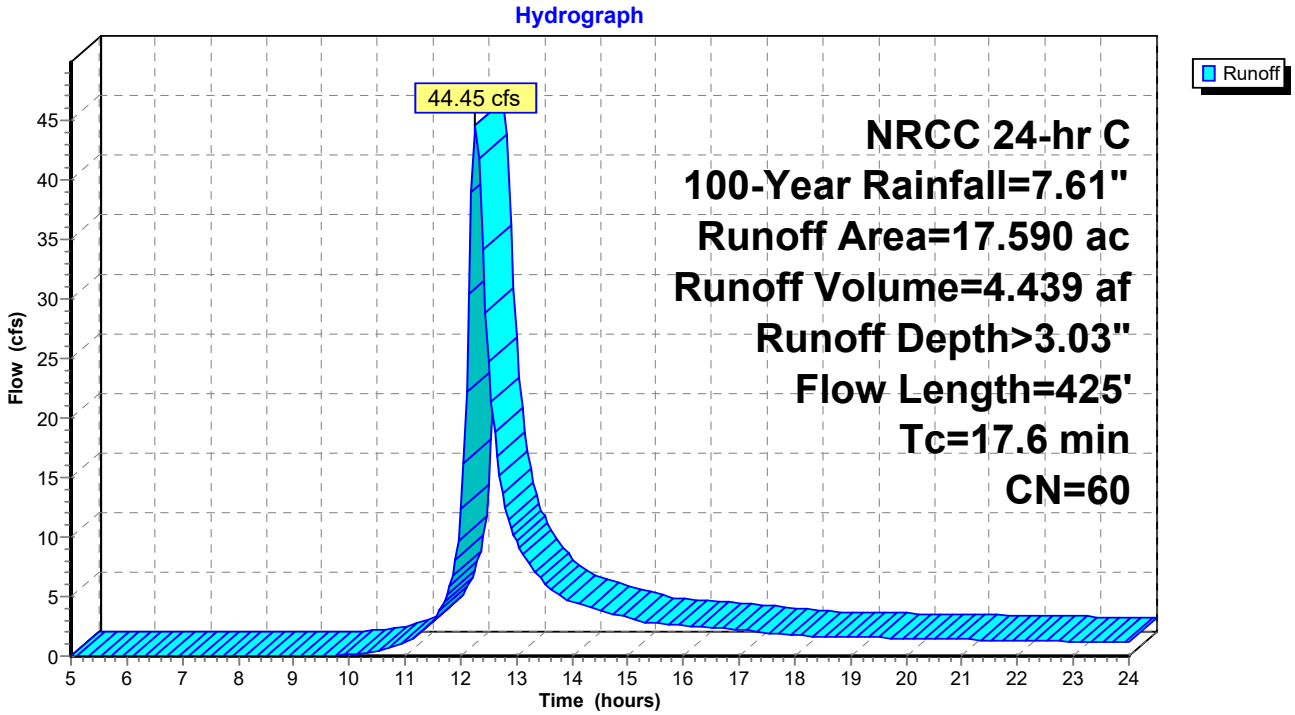
Runoff = 44.45 cfs @ 12.27 hrs, Volume= 4.439 af, Depth> 3.03"
Routed to Reach 2R : To Stream

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
NRCC 24-hr C 100-Year Rainfall=7.61"

Area (ac)	CN	Description
1.900	39	>75% Grass cover, Good, HSG A
5.420	36	Woods, Fair, HSG A
10.270	77	Woods, Good, HSG D
17.590	60	Weighted Average
17.590		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.5	50	0.0200	0.07		**Sheet Flow, sheet flow** Woods: Light underbrush n= 0.400 P2= 3.14"
5.1	375	0.0600	1.22		**Shallow Concentrated Flow, shallow concentrated flow** Woodland Kv= 5.0 fps
17.6	425	Total			

Subcatchment 2S-U: Area 2 (undetained)



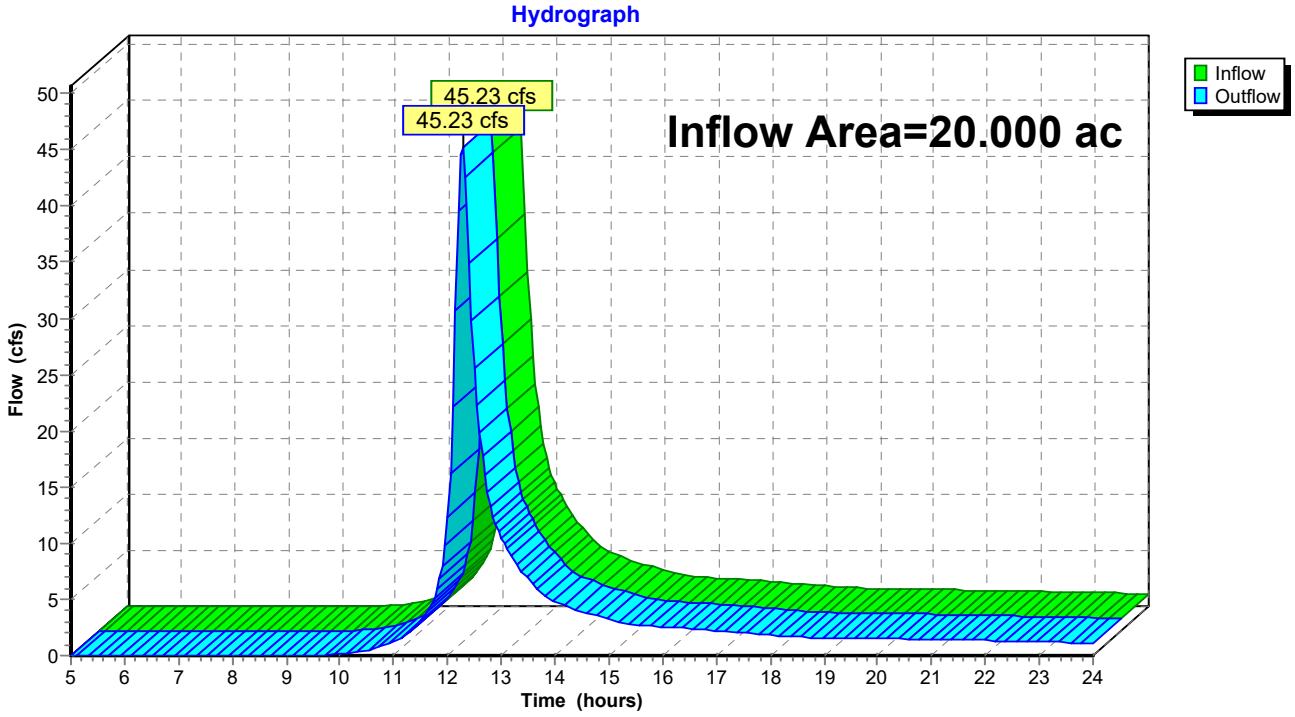
Summary for Reach 2R: To Stream

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

Inflow Area = 20.000 ac, 6.40% Impervious, Inflow Depth > 2.73" for 100-Year event
Inflow = 45.23 cfs @ 12.27 hrs, Volume= 4.554 af
Outflow = 45.23 cfs @ 12.27 hrs, Volume= 4.554 af, Atten= 0%, Lag= 0.0 min
Routed to nonexistent node 10R

Routing by Stor-Ind+Trans method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs

Reach 2R: To Stream



Summary for Pond 1P: Rain Garden Det. Basin 1

Inflow Area = 0.850 ac, 16.47% Impervious, Inflow Depth > 1.91" for 100-Year event
Inflow = 1.84 cfs @ 12.15 hrs, Volume= 0.136 af
Outflow = 0.35 cfs @ 12.68 hrs, Volume= 0.135 af, Atten= 81%, Lag= 32.1 min
Discarded = 0.35 cfs @ 12.68 hrs, Volume= 0.135 af

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 101.02' @ 12.68 hrs Surf.Area= 1,861 sf Storage= 1,444 cf

Plug-Flow detention time=37.1 min calculated for 0.135 af (99% of inflow)
Center-of-Mass det. time=35.7 min (926.8 - 891.2)

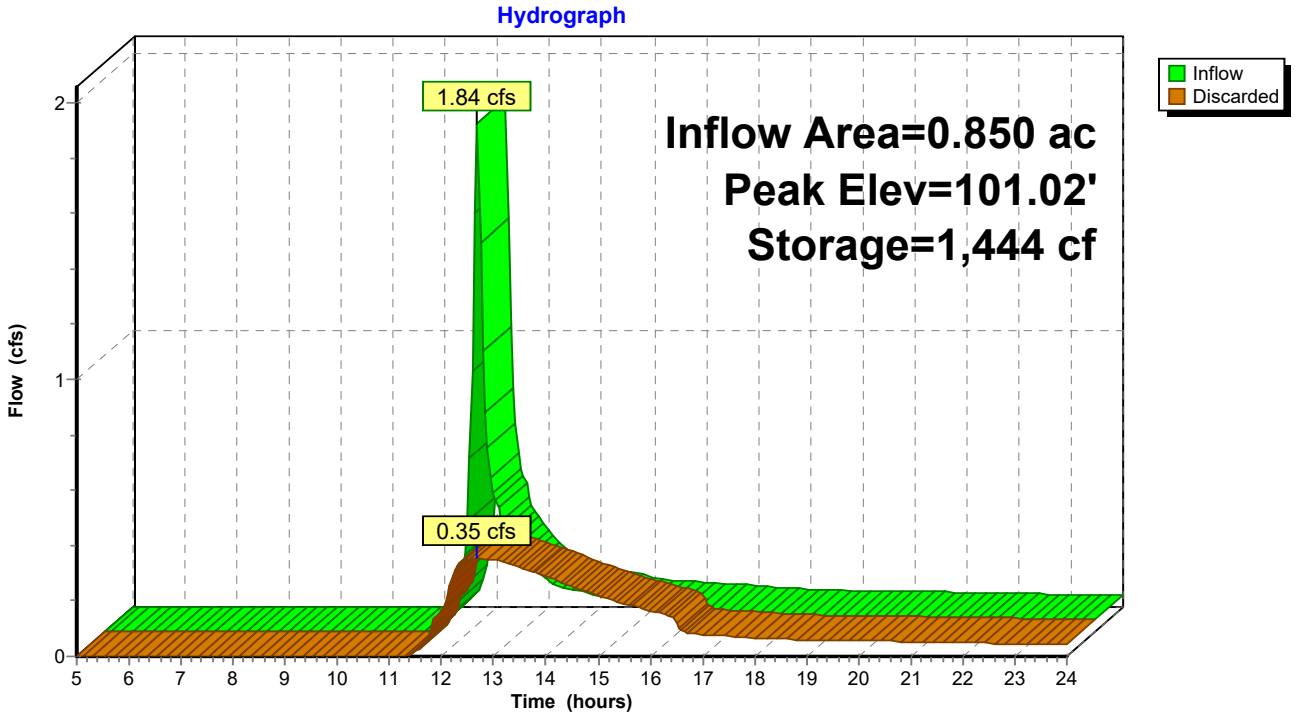
Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	14,444 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	976	0	0
101.00	1,847	1,412	1,412
102.00	2,624	2,236	3,647
103.00	3,266	2,945	6,592
104.00	3,963	3,615	10,207
105.00	4,511	4,237	14,444

Device	Routing	Invert	Outlet Devices
#1	Discarded	100.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 98.00'

Discarded OutFlow Max=0.35 cfs @ 12.68 hrs HW=101.02' (Free Discharge)
↑—**1=Exfiltration** (Controls 0.35 cfs)

Pond 1P: Rain Garden Det. Basin 1



Summary for Pond 2P: Rain Garden/Det. Basin 2

Inflow Area = 2.410 ac, 53.11% Impervious, Inflow Depth > 4.12" for 100-Year event
Inflow = 11.55 cfs @ 12.15 hrs, Volume= 0.828 af
Outflow = 2.44 cfs @ 12.54 hrs, Volume= 0.826 af, Atten= 79%, Lag= 23.7 min
Discarded = 1.48 cfs @ 12.54 hrs, Volume= 0.711 af
Primary = 0.96 cfs @ 12.54 hrs, Volume= 0.115 af
Routed to Reach 2R : To Stream

Routing by Stor-Ind method, Time Span= 5.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 95.63' @ 12.54 hrs Surf.Area= 5,835 sf Storage= 12,233 cf

Plug-Flow detention time=80.4 min calculated for 0.824 af (99% of inflow)
Center-of-Mass det. time=78.5 min (915.8 - 837.3)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	31,979 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

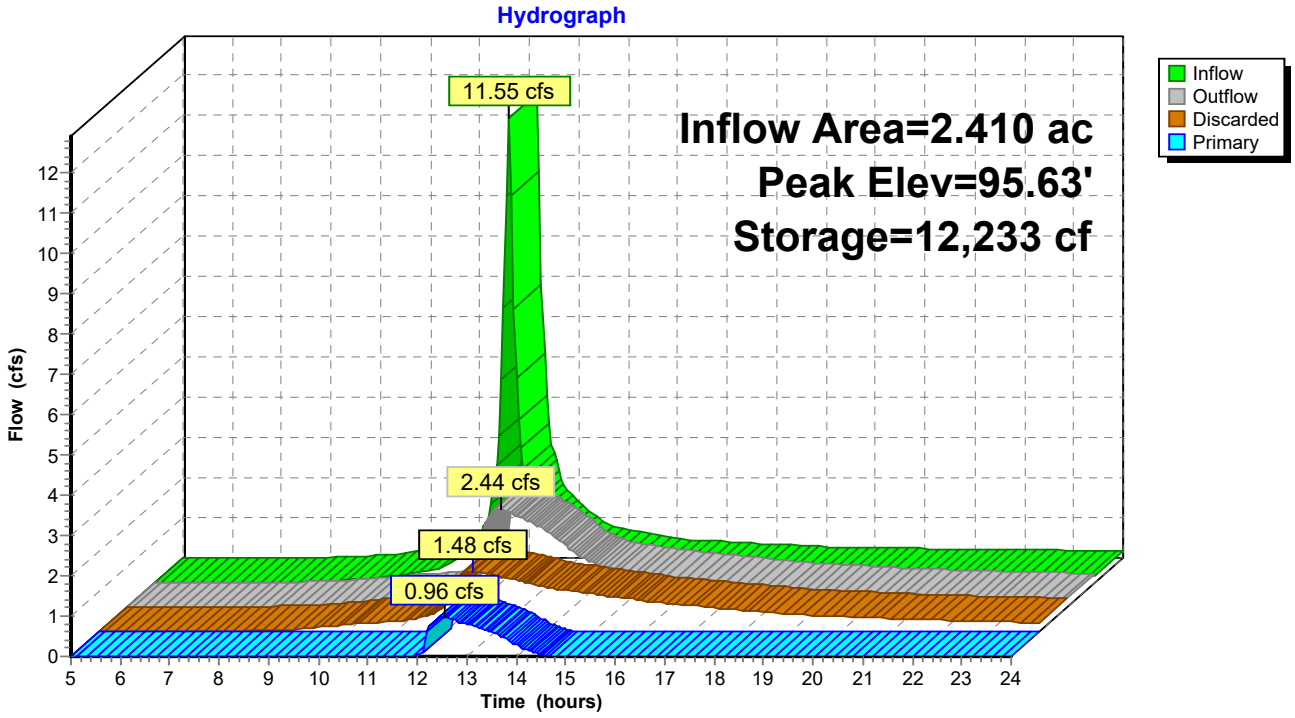
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
92.00	1,515	0	0
93.00	2,293	1,904	1,904
94.00	3,344	2,819	4,723
95.00	4,907	4,126	8,848
96.00	6,380	5,644	14,492
97.00	7,894	7,137	21,629
98.00	12,807	10,351	31,979

Device	Routing	Invert	Outlet Devices
#1	Primary	94.50'	**6.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Primary	95.50'	**12.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	97.00'	**1.5" x 1.5" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#4	Discarded	92.00'	**6.000 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 90.00'

Discarded OutFlow Max=1.48 cfs @ 12.54 hrs HW=95.63' (Free Discharge)
└**4=Exfiltration** (Controls 1.48 cfs)

Primary OutFlow Max=0.96 cfs @ 12.54 hrs HW=95.63' (Free Discharge)
├**1=Orifice/Grate** (Orifice Controls 0.89 cfs @ 4.52 fps)
├**2=Orifice/Grate** (Orifice Controls 0.07 cfs @ 1.23 fps)
└**3=Orifice/Grate** (Controls 0.00 cfs)

Pond 2P: Rain Garden/Det. Basin 2



Phineas - Post-Development-final
Prepared by O'Hara Engineering Svs

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O'Hara
Engineering Services, LLC

21 Mansion Drive
Lowell, MA 01852
Tel. (617) 312-4629
mark.ohara@verizon.net

Operations and Maintenance Manual

Louis Farm Village,
133 Phineas Street
Dracut, MA 01826

April 14, 2022

Introduction

Stormwater runoff is the water from rain and snow melt that flows across land. Pollutants that have been deposited on land are carried by runoff into nearby rivers, streams, lakes, ponds wetlands, marine waters and groundwater. This contaminated runoff significantly degrades water quality and aquatic habitat. Stormwater runoff also may increase flooding and erosion.

Development increases stormwater runoff, which alters natural drainage features, increases flooding, and may reduce the groundwater recharge to support wetlands and maintain base flows in streams. Development also increases the concentration and types of pollutants that can be carried by runoff, including nutrients, solids, metals, salt, pathogens, pesticides, and hydrocarbons.

In Massachusetts, stormwater runoff and discharges from stormwater drainpipes are the largest contributors to water quality problems in the Commonwealth's rivers, streams, and marine waters. The state's surface water quality standards, which identify and protect water uses such as water supplies and fish and wildlife habitat, have not been met in many locations. Recent data show that urban runoff and stormwater are responsible for 46 percent of assessed river segments not supporting their designated use and 48 percent of assessed marine waters not supporting their designated use. (Massachusetts Department if Environmental Protection, Commonwealth of Massachusetts: Summary of Water Quality, 1995; based on assessment data on all principal mainstem rivers and their major tributaries, not all surface waters.)

To protest the wetlands and waters of the Commonwealth from the adverse impacts of stormwater runoff, DEP issued a Stormwater Management Policy in November 1996 (revised in February 2008) concurrently with its Guidance for the Rivers Protection act. With the input of the state's Stormwater Advisory Committee, DEP developed the policy to address stormwater impacts through implementation of performance standards under existing environmental protection programs. The Stormwater Management Standards establish clear and consistent guidelines for stormwater management in Massaschusetts while streamlining the regulatory process. The Standards address both water quality (pollutants) and water quality (flood control) be establishing the level of required controls which can be achieved though the use of site planning, nonstructural measures and Best Management Practices (BMP's). BMP's reduce or prevent pollutants from reaching water bodies and control the quality of runoff from a site. The Standards are designed to meet the stormwater management requirements under various regulatory programs, and:

- Prevent untreated discharges to wetlands and waters;
- Preserve hydrologic conditions that closely resemble pre-development conditions;
- Reduce or prevent flooding by managing the peak discharge and volumes of runoff;
- Minimize erosion and sedimentation;
- Reduce suspended solids and other pollutants to improve water quality; and
- Provide increased protection of sensitive natural resources.

This Operations and Maintenance Manual has been prepared to assist Owners with the required inspection and maintenance of stormwater management devices to ensure compliance with the Stormwater Management Policy. It is the responsibility of the Owner to insure that routine maintenance and inspections are carried out in accordance with the schedules included herein.

Identification of Owner:

The Owner of the Best Management Practice (BMP) is the person, persons or entity upon which land the BMP is located.

Owner (at time of filing): 133 Phineas Street, LLC
2100 Lakeview Ave, Unit B
Dracut, MA 01826

Identification of Party Responsible for Operation and Maintenance of BMP's:

The **Owner** of the BMP is the party responsible for Operation and Maintenance.

Location of Public Safety Features:

An **Emergency Spill Kit** will be located onsite at the staging area/site trailer containing:
- Protective Safety Goggles,
- Masks,
- Gloves,
- Salvage Drum,
- Heavy Duty garbage bags,
- Absorption materials (Chem-sorb absorbants, pads, pillows and socks),
- Caution signs and tape

Estimated Budget:

- Spill kit: $500
- Inspections: By designated qualified on-site employee. Tasks performed daily, and as needed (hourly rate)
- Maintenance: As needed (hourly rate)
- Annual inspection report by qualified engineer: estimated $2000

Description of BMP's used on this site:

- Street Sweeping;
- Deep Sump Hooded Catchbasins
- Rain Gardens/Detention Basins;
- Stone Rip-rap and overflow swales;

Street Sweeping:

Street sweeping is both a temporary and permanent BMP. Street sweeping is an effective tool to capture sedimentation buildup on roadways in non-point source pollution control. During construction it is imperative that street sweeping schedules be conducted often in accordance with the NPDES Stormwater Pollution Prevention Plan.

Purpose:

- To remove debris, sediment and hydrocarbons from stormwater runoff;
- To provide pre-treatment for other BMPs

Inspection and Maintenance:
Street sweeping should be performed often during construction in accordance with the schedules prepared under the NPDES Stormwater Pollution Prevention Plan. When development has been completed, street sweeping should be performed in accordance with the street sweeping program. The ability of street sweeping efforts to remove pollutants which accumulate on roads is proportional to the frequency of the street sweeping schedule. It is recommended that street sweeping be conducted immediately following winter snowmelt, when sand and other sediment is washed off and once per month during late spring, summer and early fall seasons.

Deep Sump Hooded Catch Basins:

Deep sump catch basins are permanent BMP's. They are designed to remove trash, debris, and some amount of sediment and oil and grease from stormwater runoff.
The deep sump catch basin has the stormwater runoff inflow at the top of the basin (grate). Stormwater flows through the grate and into the chamber, which may contain a permanent pool of water. The stormwater must then pass under the hood before being discharged. The hood helps trap oil and grease float on the permanent pool water. Eventually, the oil and grease will attach to sediment and settle out.

Stone Rip/Rap:

Stone Rip/Rap is a permanent BMP. Stone Rip/Rap consists of large, loose, angular stone set onto granular underlining or filter fabric. It is used to slow the velocity of runoff at headwalls and flared end sections, in overflows and swales and also to stabilize slopes.

Purpose:

- To protect soil from erosive forces of concentrated runoff;
- To slow the velocity of runoff;
- To provide stabilization of overflow swales and slopes.

Inspection and Maintenance:
During construction, rip/rap should be inspected weekly and after all large storm events to determine if high flows have caused scour beneath the rip/rap or filter fabric or dislodged any of the stone. Thereafter, it should require very little maintenance. It should, however, be inspected twice annually and after all major storm events. Accumulated sedimentation shall be removed and disposed of in accordance with all applicable local, state, and federal guidelines and regulations.

Appendix:

The attached water quality fact sheets can be found at the Massachusetts Department of Environmental Protection (MADEP) website:

Lawn maintenance (composting & organics):
http://www.mass.gov/dep/recycle/reduce/dtg.htm

Guide to Lawn and Landscape Water Conservation:
http://www.mass.gov/envir/mwrc/pdf/LawnGuide.pdf

Ecological Landscaping Tools for Massachusetts Homeowners:
http://www.mass.gov/envir/mwrc/pdf/More_Than_Just_Yard.pdf

Fertilizer Storage:
http://www.mass.gov/dep/water/drinking/fert.pdf

Vehicle Washing:
http://www.mass.gov/dep/water/resources/carwash.htm

Pet waste:
http://www.mass.gov/dep/water/resources/petwaste.htm

Household hazardous waste:
http://www.mass.gov/dep/recycle/reduce/househol.htm

Information on spills and contamination for homeowners:
http://www.mass.gov/dep/cleanup/homeownr.htm

Don't Trash Grass

Save time and money! Reduce waste!

Did you know that a 1/2 acre lawn in New England produces more than 3 tons or nearly 260 bags of grass clippings each year? Think of all the time, money and effort it would take to bag all those clippings. Why go through all that hassle when it's really not necessary? You can have a healthy green lawn by leaving grass clippings where they fall! It's simple...grass clippings left on the lawn will decompose and act as a natural organic fertilizer. This allows you to reduce the amount of additional commercial fertilizer you need to apply. Your lawn will still be healthy and green because each time you mow, you will be returning valuable nutrients to the soil!

The key word is "less"...less fertilizer, less water, less work, and best of all, less waste! Recycling clippings back into the lawn requires less effort than disposing of them as waste. No one has to handle the clippings - not you, not your lawn care professional and not the waste management crew. You can reduce your mowing time by nearly 40 percent by not bagging, and spend less money on fertilizer and trash bags. And by not trashing grass, you'll be doing your part for the environment by reducing waste! If you follow these "Don't Trash Grass" mowing, fertilizing and watering guidelines, not only will you have a healthy lawn, but you'll never have to bag grass clippings again!

Mowing techniques and tips

Any mower can recycle grass clippings. Simply remove the grass catcher! Ask your lawn mower dealer if a special safety plug or adapter kit is needed to convert your mower into a "recycling" mower. You can also have a mulching blade installed.

- Keep your grass mowed to 2 to 3 inches tall.
- Do not remove more than 1/3 of the grass blade in any single mowing. For example, if your lawn is kept at 2 inches tall, it should not be allowed to grow higher than 3 inches before it is mowed again.
- Mow when the grass is dry.
- Keep your mower blade sharp because dull mowers tear the grass blade, injuring the plant, and create a brownish cast to the turf.
- If the grass gets just a bit too high, simply mow over the clippings a second time to further shred and scatter them.
- If excessive growth occurs between mowings, raise the mower height, mow and then gradually lower it over a span of several mowings. This will help prevent shock to the plants.
- When it's time to replace your mower, consider buying a mulching, recycling, or a non-polluting reel mower.

Fertilizer application

Proper fertilizer application is important. And remember, when it comes to fertilizer, more is not better! Research shows that most grasses require only modest levels of nitrogen for good color and controlled growth. Too much fertilizer will make your lawn grow faster, resulting in more mowing and more clippings!

Apply fertilizer to your lawn in late April and again in September. If a third treatment is needed, apply in late May. Apply only 1/2 pound of nitrogen per 1000 square feet of lawn at each application. To figure this out, simply divide 100 by twice the percentage of nitrogen (N) in the fertilizer. This will give you the application rate in pounds of fertilizer per 1000 square feet of lawn.

Fertilizer N-P-K rating (%)	Divide 100 by twice the % of Nitrogen(N)	Pounds of fertilizer to use per 1000 sq.ft.
12-4-8	100 divided by 24	= 4.1 lbs
16-8-8	100 divided by 32	= 3.1 lbs
20-5-10	100 divided by 40	= 2.5 lbs
10-10-10	100 divided by 20	= 5.0 lbs

For slower, more uniform growth, choose fertilizers containing sources of slow-release nitrogen such as methylene urea, ureaformaldehyde, sulfur coated urea, or IBDU. The bag may also read "water insoluble nitrogen" or "slow release nitrogen". All are acceptable and will increase the amount of time the grass can use the nutrient. Watering practices New England has a high precipitation rate, so turf grasses here don't have to be watered to survive. Lawns may turn brown and dormant during periods of drought, but will turn green rapidly when moisture in the soil is replaced. Remember, the more you water your lawn, the faster it's going to grow and the more you will have to mow it!

Watering your lawn

- Conserve resources by not watering unless the grass really needs it. Let Mother Nature water your lawn!
- If you choose to water, 1 inch of water is adequate to wet the soil to a depth of 4 to 6 inches. Place an empty can under the sprinkler to measure when an inch has been applied. If water begins to run off the lawn before an inch is applied, turn off the water and let it soak in for an hour or so, then resume watering until 1 inch is applied.
- Water deeply and less frequently to encourage deep root growth. Light, frequent watering encourages shallow roots and may lead to increased disease and stress injury.
- The best time to water is in the morning because less water is lost through evaporation and transpiration.

- Avoid watering during mid-day and try not to water in the evenings since a lawn that remains damp during the night is more prone to disease.

What about thatch?

Don't worry about grass clippings contributing to thatch problems. Turf experts nationwide agree that clippings do not produce thatch because they are 80 percent water and decompose quickly. Rather, thatch is the accumulation of dead roots and stems and is most often caused by overfertilizing and over watering. A thatch layer of more than 1/2 inch should be removed as a matter of healthy lawn maintenance.

Other uses for clippings

Compost clippings at home: Clippings are an excellent source of nitrogen for your compost pile. No more than 1/3 of the pile should be fresh clippings. Mix thoroughly with "brown" materials such as leaves or straw and turn the pile regularly to keep it well oxygenated and to prevent odors. Use clippings as mulch: Apply dried grass clippings directly on the soil about 1 inch thick to reduce weeds, moderate soil temperature, and control soil spattering, erosion,run-off and evaporation. Avoid mulching with clippings which have been recently treated with herbicides. This can harm your plants. As a precaution, mulch with clippings from herbicide treated lawns only after two lawn mowings. Incorporate clippings into garden soil: Mixing fresh grass clippings into the garden adds nutrients and organic matter which improves the texture and moisture retention properties of the soil. A two inch layer of grass can be turned into the soil to a depth of 6 inches about once a month.

Alternative landscapes

Consider planting ground covers such as English ivy, pachysandra, and periwinkle; increasing shrub beds; or growing a wildflower meadow as alternatives to turfgrass. They look beautiful, don't need mowing and will help reduce lawn maintenance and yard waste!

A MASSACHUSETTS BUREAU OF FARM PRODUCTS & PLANT INDUSTRIES FACT SHEET

Protecting Water Sources from Fertilizer

Fertilizers used to promote plant growth and lush green lawns also have the potential to contaminate water sources if applied improperly. The principle components of fertilizer are Nitrogen, Phosphorus and Potassium (N-P-K). **Nitrogen** is the main nutrient for new, green growth, **Phosphorus** promotes root development and **Potassium** improves the overall health of plants. Excessive amounts of nitrogen and phosphorus are the nutrients most likely to adversely affect water quality.

You can prevent ground and surface water contamination by observing the following practices when buying and applying fertilizers:

- **Test your soil.** Soil testing is the most critical step in any lawn fertility program by providing the information needed to select the fertilizer with the N-P-K value best suited to the nutritional needs of your soil. If you use a lawn care service insist they test your soil before any applications are made.
- **Use a slow-release nitrogen fertilizer.** There are two basic forms of nitrogen contained in fertilizer products: **fast-release** or Water Soluble Nitrogen (WSN), and **slow-release** or Water Insoluble Nitrogen (WIN). Slow-release fertilizers provide a more controlled release of nitrogen thereby limiting the amount of fertilizer leaching into groundwater. Also remember that **weed and feed** fertilizers contain pesticides which pose additional risks to water sources.
- **Use iron as a supplement to nitrogen.** Iron can be used alone or in combination with nitrogen to provide a greening response. Adding iron will decrease the amount of nitrogen needed thereby minimizing the amount of nitrate leaching into water sources.
- **Choose the proper spreader and calibrate it correctly.** By using a drop spreader instead of a rotary spreader near water supply sources and storm drains, you decrease the risk of fertilizer contamination. Proper calibration helps prevent misapplication of the fertilizer.

- **Time your fertilizer applications.** Fast-acting fertilizers should not be applied before a heavy rainfall. Spring fertilization should be minimized—water tables are generally high at that time, thereby increasing the risk of fertilizer leaching into water sources. Do not apply fertilizer on frozen ground—the likelihood of runoff into water supply sources is dramatically increased. Avoid fall nitrogen applications on coarse-textured soils. These soil types have low water holding capacities and a high potential of nitrate leaching.

- **Use buffer strips.** Leave a strip of unfertilized grasses or natural vegetation near any water body. This helps against erosion and produces a trap for unwanted nutrients.

- **Minimize fertilizer rates on slopes.** The potential for runoff is decreased if you limit the amount of fertilizer in these locations.

- **Use a mulching mower.** Mulching the grass and leaving the clippings reduces the need for fertilizer by as much as one-half.

- **Prevent misapplication of fertilizers.** Take care when applying fertilizers around sewers and drains. Shut off spreaders before crossing sidewalks or driveways and sweep up any spills. Rinse your spreader over the lawn area and not on the driveway in order to minimize fertilizer runoff.

- **Properly store your fertilizer.** Unused fertilizer should be removed from the spreader and returned to the original bag or container for future use. Store unused fertilizer in a dry place away from any water source. If stored fertilizer gets wet you not only lose nutrient value, there is potential for nitrates to leach into water sources.

Fertilizers should not be applied within the Zone I protective radius of a public drinking water supply.

Any questions or concerns about fertilizer use should be directed to:

The Bureau of Farm Products and Plant Industries at the Massachusetts Department of Food and Agriculture (DFA), 251 Causeway Street, Boston, MA 02114. Telephone: 617- 626-1700. Website: www.massdfa.org

For information on protecting water sources from Pesticides refer to the Pesticide Fact Sheet

When you wash your car in the driveway,
Remember
you're not *just* washing your car in the driveway.

All the soap, scum, and oily grit runs along the curb. Then into a storm drain and directly into our lakes, rivers, and streams. And that causes pollution which is unhealthy for everyone. So how do you avoid this whole mess? Easy! Wash your car on the grass or gravel instead of the street. Or better yet, take it to a car wash where the water gets treated or recycled.

Clean water is important to all of us.

It's up to all of us to make it happen. In recent years, sources of water pollution like industrial wastes from factories have been greatly reduced. Now, more than 60 percent of water pollution comes from things like cars leaking oil, fertilizers from farms and gardens, and failing septic tanks. All these sources add up to a big pollution problem. But each of us can do small things to help clean up our water too—and that adds up to a pollution solution!

Why do we need clean water?

Having clean water is of primary importance for our health and economy. Clean water provides recreation, commercial opportunities, fish habitat, drinking water, and adds beauty to our landscape. All of us benefit from clean water—and all of us have a role in getting and keeping our lakes, rivers, streams, marine, and ground waters clean.

What's the problem with car washing?

There's no problem with washing your car. It's just how and where you do it. The average driveway car wash uses a total of 116 gallons of water! Most commercial car washes use 60 percent less water in the entire washing process than a simple home wash uses just to rinse off a car. Most soap contains phosphates and other chemicals that harm fish and water quality. The soap, together with the dirt and oil washed from your car, flows into nearby storm drains which run directly into lakes, rivers, or marine waters. The phosphates from the soap can cause excess algae to grow. Algae look bad, smell bad, and harm water quality. As algae decays, it uses up oxygen in the water that fish and other wildlife need.

Clean Water Tips:

How can you wash your car and help keep our waters clean?

Use soap sparingly. Use a hose nozzle with a trigger to save water.

Pour your bucket of soapy water down the sink when you're done, not in the street. Or wash your car on a grassy area so the ground can filter the water naturally.

Best of all, take your car to a commercial car wash, especially if you plan to clean the engine or the bottom of your car. Most car washes reuse wash water several times before sending it to the sewer system for treatment.

To find out more about the impacts of nonpoint source pollution and what you can do to prevent it, call the numbers listed below.

MDC
617/727-5114

617/626-1540

EPA New England
617/918-1111

617/292-5500

CZM
617/626-1250

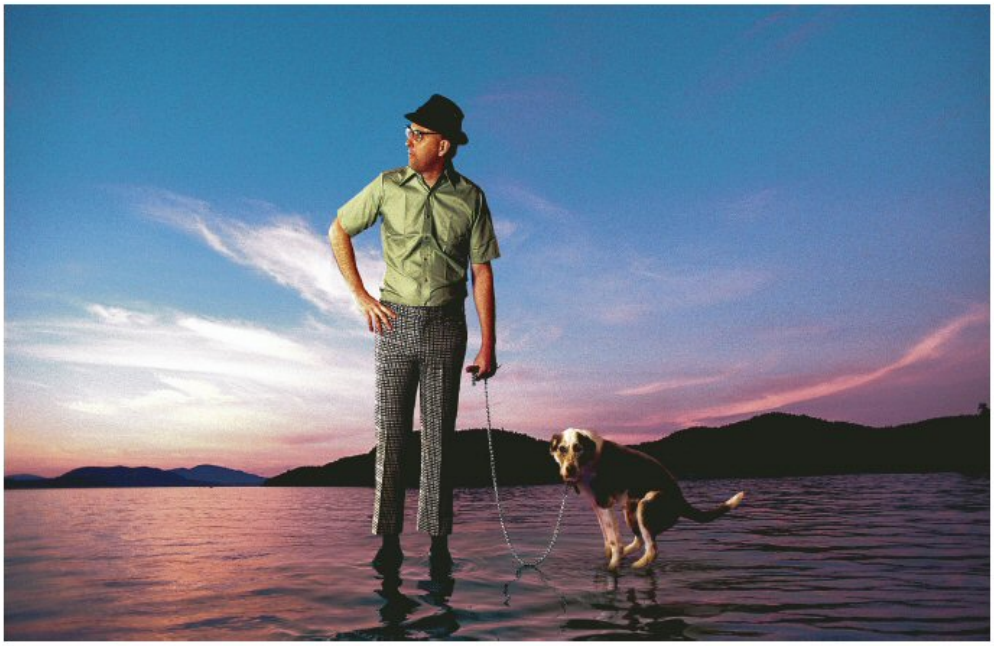
MDFA
617/626-1700

617/626-1395

Communities Connected by Water
Massachusetts Watershed Initiative
617/626-1000

This information on nonpoint source pollution is brought to you by the Department of Environmental Protection, the Executive Office of Environmental Affairs' Massachusetts Watershed Initiative, Coastal Zone Management, the Department of Environmental Management, the Department of Fisheries, Wildlife, and Law Enforcement, the Department of Food and Agriculture, and the Metropolitan District Commission working to reduce nonpoint source pollution through public education. This project was funded by the U.S. Environmental Protection Agency with a federal 104(b)(3) grant.

When your pet goes on the lawn
Remember
it doesn't *just* go on the lawn.



When our pets leave those little surprises, rain can wash pet waste and bacteria into our storm drains that can pollute our waterways. So what to do? Simple! Dispose of it properly. Then that little surprise gets treated like it should.