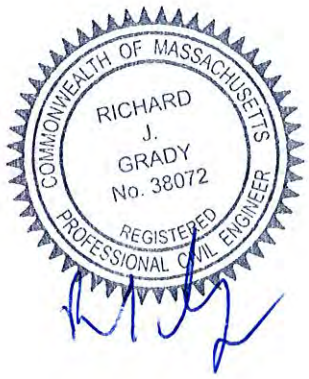
GRADY CONSULTING, L.L.C.

Civil Engineers ♦ Land Surveyors ♦ Landscape Architects

STORMWATER REPORT

Proposed Commercial Building
540 Bodwell Street, Ext.
Avon, Massachusetts



Prepared for:

CJ Shaughnessy Realty Trust
520 Bodwell Street Ext.
Avon, MA 02322

June 29, 2020

71 Evergreen Street, Suite 1 • Kingston, MA 02364 • Tel (781) 585-2300 • Fax (781) 585-2378

SUMMARY

This Stormwater Report has been prepared to document compliance with Stormwater Management Standards. The applicant is proposing to redevelop approximately 35,500 sf of an existing 59,048 sf lot. The project consists of razing an existing building and pavement areas and constructing a new 160' long x 85' wide building and associated parking areas.

The proposed drainage system consists of a bio-retention basin to attenuate runoff from the roof of the proposed building. The proposed development reduces the impervious coverage by approximately 700 sf, therefore reducing peak runoff rates and volume.

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

This analysis is divided into the following sections:

Section I	Compliance with Massachusetts Stormwater Management Regulations
Section II	Overall Site Analysis
Section III	Operation and Maintenance Plan

The calculations have been performed for the 2, 10, and 25, 100-year 24 hour storm event, using HydroCAD 10.00 Stormwater Modeling computer program. This computer program is based upon the TR-55 computer models and uses the SCS Curvilinear Unit rainfall distribution. The closed drainage system calculation were performed using the HydroCAD Stormwater Modeling program.

SUMMARY OF STORMWATER FLOWS
(cfs)

Flow to Northwest and East Wetland

Design Storm		Existing Condition 9L(Pre 2 and 3)	Proposed Condition 8L(POST 2-6)
2-year	3.4”	3.44	2.62
10-year	4.7”	4.96	4.58
25-year	5.6”	6.00	5.62
100-year	7.0”	7.61	7.24

Flow to Southeast Catch Basin and Wetland

Design Storm		Existing Condition 1 PRE	Proposed Condition 1 POST
2-year	3.4”	1.20	1.05
10-year	4.7”	1.77	1.57
25-year	5.6”	2.17	1.93
100-year	7.0”	2.78	2.49

Bio-Retention Basin (7R)
(No Infiltration)

Design Storm		Max El. (ft)	Storage (cf)	Peak Inflow	Outflow (Weir)
2-year	3.4”	197.59	1,852	1.24	0.90
10-year	4.7”	197.64	1,954	1.81	1.68
25-year	5.6”	197.66	2,000	2.21	2.07
100-year	7.0”	197.69	2,067	2.85	2.68

Section I

Compliance with Massachusetts Stormwater Management Regulations

STANDARD 1. NO NEW STORMWATER CONVEYANCES
The proposed development proposes no new stormwater conveyances that discharge untreated stormwater off-site or cause down gradient erosion.

STANDARD 2. PEAK RATE ATTENUATION
The overall site analysis demonstrates that the stormwater management system has been designed so that the post-development peak discharge rates do not exceed the pre-development discharge rate.

STANDARD 3. STORMWATER RECHARGE
Based on Plymouth County Soil Survey, and soils testing conducted on the adjacent property, it was determined that the site consists of Hydrologic Soils Group "Type C".

TABLE 1
REQUIRED RECHARGE VOLUME AND DRAWDOWN

Impervious Area = 31,225 SF
Target Depth Factor (F) = 0.25"

Rv = F x impervious area = 0.25"x 31,225 SF x 1'/12"= 650.5 CF

Total Required Recharge =650.5 CF

Proposed:
Bio-Retention Basin (below outlet weir elevation 197.50) = 1,661 CF Provided

Drawdown Within 72 Hours

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

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

Basin #1

$$\text{Time} = \frac{1{,}661\ \text{CF}}{(0.27\text{"/hr})(1\text{'/12"})(1{,}384\ \text{SF})} = 53.4\ \text{hours} < 72\ \text{hours}$$

Mounding Analysis

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

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

This mounding will not interfere with dewatering within 72 hours or result in break out above the land or water surface of a wetland.

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

STANDARD 4. WATER QUALITY

TSS Removal

The proposed work meets the requirement for removal of total suspended solids (TSS). See TSS Removal Worksheet

Long-Term Pollution Prevention Plan

The long-term pollution prevention plan will be combined with the Operation and Maintenance Plan required by Standard 9.

WATER QUALITY TREATMENT VOLUME

V_{WQ} = (D_{WQ}/12 inches/foot) * (A_{IMP} * 43,560 square feet/acre)

V_{WQ} = *Required Water Quality Volume* (in cubic feet)
D_{WQ} = Water Quality Depth: one-inch for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from a LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hour or greater; ½-inch for discharges near or to other areas.
A_{IMP} = Impervious Area (in acres)

The site is not located in soils with an infiltration rate greater than 2.4 inches/hour so a Water Quality Depth of 1/2-inch is required.

V_{WQ} = (0.5 inch/12 inches/foot) * (31,225 square feet) = 1,301 CF

1,661 CF storage volume provided in the bio-retention basin below the drainage system outlet.

STANDARD 5 LAND USES WITH HIGHER POTENTIAL POLLUTANT LOADS

The land use is not considered a higher potential pollutant load.

STANDARD 6. CRITICAL AREAS

The land use is not located within a critical area.

STANDARD 7. REDEVELOPMENT PROJECT

"A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural stormwater best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions."

The project is a redevelopment project. The proposed redevelopment reduces the impervious coverage on the site and proposes a bioretention basin. Post development peak rates and volumes have been reduced through the decrease in impervious areas and proposed bio-retention basin.

STANDARD 8. CONSTRUCTION PERIOD CONTROLS

A plan to control construction-related impacts, including erosion, sedimentation, and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.

The proposed project will not disturb more than one acre of land and is not required to obtain coverage under the NPDES Construction General Permit issued by EPA and prepare a Stormwater Pollution Plan (see attached O&M Plan during construction)

STANDARD 9. LONG-TERM OPERATION AND MAINTENANCE (O&M) PLAN

A Long -Term Operation and Maintenance (O&M) Plan shall be developed and implemented to ensure that stormwater management systems function as designed.

The Long-Term Operation and Maintenance Plan shall at a minimum include:

1. *Stormwater management system(s) owners;*
2. *The party or parties responsible for operation and maintenance, including how future property owners will be notified of the presence of the stormwater management system and the requirement for proper operation and maintenance;*
3. *The routine and non-routine maintenance tasks to be undertaken after construction is complete and a schedule for implementing those tasks;*
4. *A plan that is drawn to scale and shows the location of all stormwater BMPs in each treatment train along with the discharge point;*
5. *A description and delineation of public safety features; and*
6. *An estimated operations and maintenance budget.*

STANDARD 10. ILLICIT DISCHARGES PROHIBITED

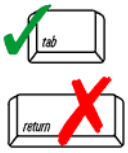
"All illicit discharges to the stormwater management system are prohibited."

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.

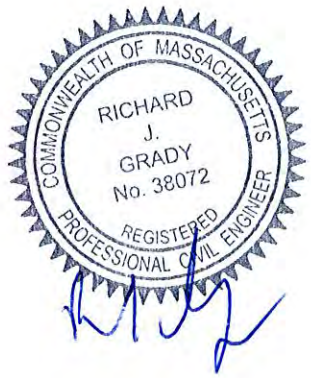
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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



Richard Grady 6/29/20

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:

- [X] No disturbance to any Wetland Resource Areas
- [ ] Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- [X] Reduced Impervious Area (Redevelopment Only)
- [X] 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
- [X] Bioretention Cells (includes Rain Gardens)
- [ ] Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- [ ] Treebox Filter
- [ ] Water Quality Swale
- [ ] Grass Channel
- [ ] Green Roof
- [ ] Other (describe): _____

Standard 1: No New Untreated Discharges

- [X] No new untreated discharges
- [ ] Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- [X] 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

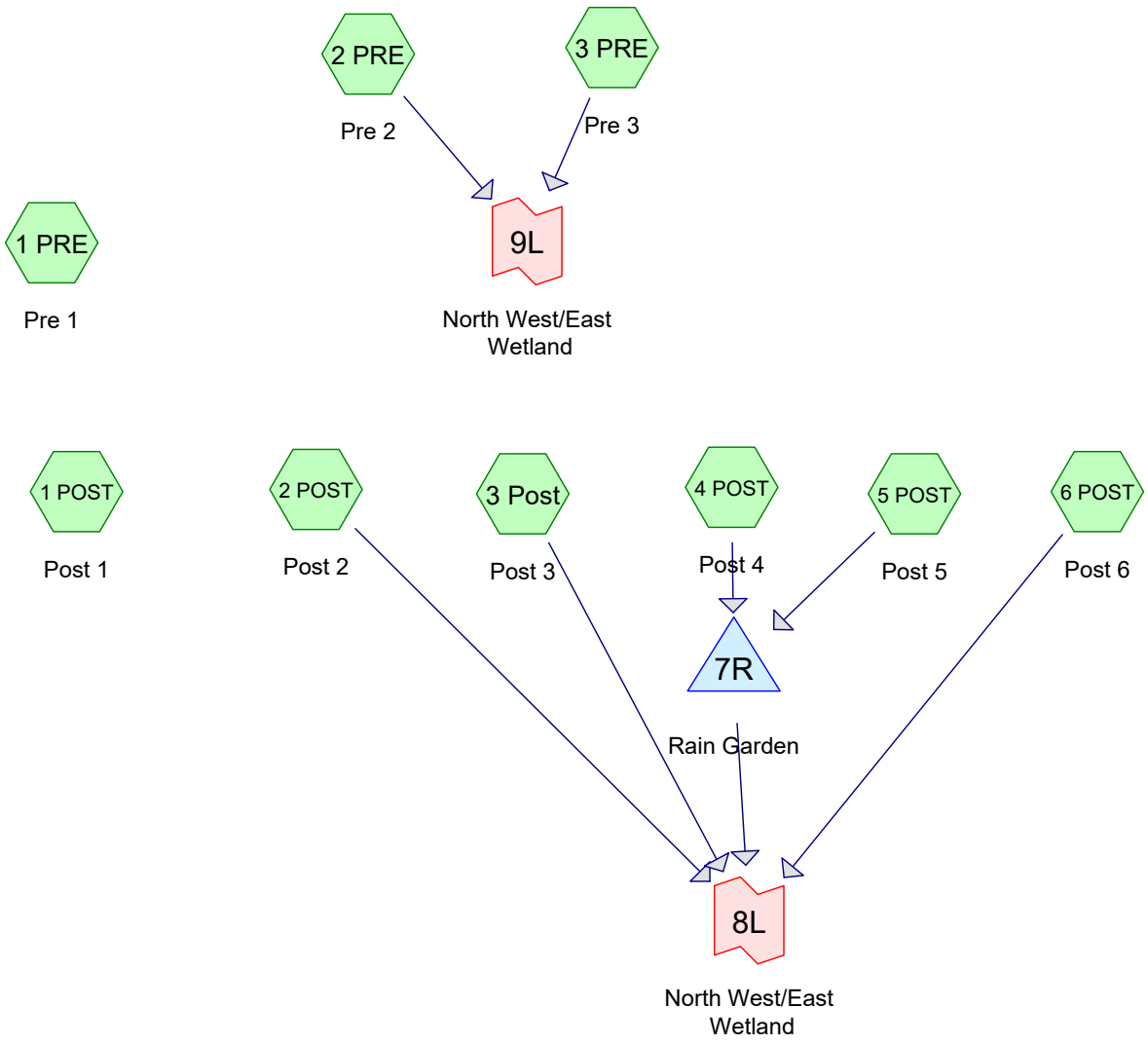
☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ 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.

Section II

Overall Site Analysis



Subcat Reach Pond Link

Routing Diagram for Stormwater
Prepared by Grady Consulting LLC
HydroCAD® 10.00-25 s/n 09955 © 2019 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
12,633	79	50-75% Grass cover, Fair, HSG C (1 POST, 1 PRE, 6 POST)
5,655	74	>75% Grass cover, Good, HSG C (5 POST)
34,500	96	Gravel surface, HSG C (2 POST, 2 PRE, 3 Post, 3 PRE)
44,229	98	Paved parking, HSG C (1 POST, 1 PRE, 2 POST, 2 PRE, 3 Post, 3 PRE)
6,631	98	Roofs, HSG C (2 PRE)
13,600	98	Unconnected roofs, HSG C (4 POST)
14,932	73	Woods, Fair, HSG C (1 POST, 1 PRE, 2 POST, 2 PRE, 3 Post, 3 PRE, 6 POST)
132,180	**92**	**TOTAL AREA**

Time span=0.10-24.00 hrs, dt=0.02 hrs, 1196 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1 POST: Post 1	Runoff Area=16,291 sf 59.03% Impervious Runoff Depth>2.35" Tc=5.0 min CN=90 Runoff=1.05 cfs 3,194 cf
Subcatchment 1 PRE: Pre 1	Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>2.44" Tc=5.0 min CN=91 Runoff=1.20 cfs 3,665 cf
Subcatchment 2 POST: Post 2	Runoff Area=17,508 sf 39.02% Impervious Runoff Depth>2.84" Tc=5.0 min CN=95 Runoff=1.30 cfs 4,142 cf
Subcatchment 2 PRE: Pre 2	Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>2.74" Tc=5.0 min CN=94 Runoff=2.82 cfs 8,866 cf
Subcatchment 3 Post: Post 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>2.44" Tc=5.0 min CN=91 Runoff=0.61 cfs 1,879 cf
Subcatchment 3 PRE: Pre 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>2.44" Tc=5.0 min CN=91 Runoff=0.61 cfs 1,879 cf
Subcatchment 4 POST: Post 4	Runoff Area=13,600 sf 100.00% Impervious Runoff Depth>3.16" Tc=5.0 min CN=98 Runoff=1.07 cfs 3,587 cf
Subcatchment 5 POST: Post 5	Runoff Area=5,655 sf 0.00% Impervious Runoff Depth>1.17" Tc=5.0 min CN=74 Runoff=0.18 cfs 551 cf
Subcatchment 6 POST: Post 6	Runoff Area=3,815 sf 0.00% Impervious Runoff Depth>1.17" Tc=5.0 min CN=74 Runoff=0.12 cfs 372 cf
Pond 7R: Rain Garden	Peak Elev=197.59' Storage=1,852 cf Inflow=1.24 cfs 4,138 cf Outflow=0.90 cfs 2,472 cf
Link 8L: North West/East Wetland	Inflow=2.62 cfs 8,865 cf Primary=2.62 cfs 8,865 cf
Link 9L: North West/East Wetland	Inflow=3.44 cfs 10,744 cf Primary=3.44 cfs 10,744 cf

Total Runoff Area = 132,180 sf Runoff Volume = 28,134 cf Average Runoff Depth = 2.55"
51.23% Pervious = 67,720 sf 48.77% Impervious = 64,460 sf

Summary for Subcatchment 1 POST: Post 1

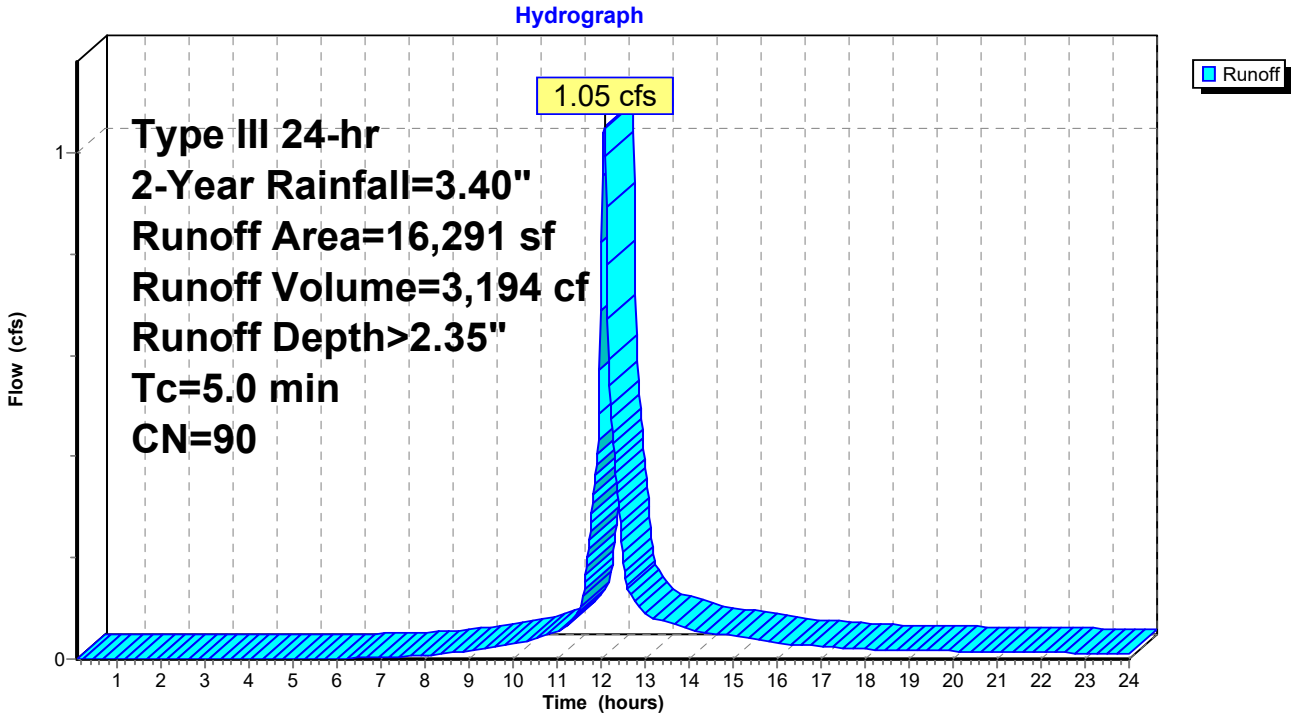
Runoff = 1.05 cfs @ 12.07 hrs, Volume= 3,194 cf, Depth> 2.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,910	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
9,617	98	Paved parking, HSG C
16,291	90	Weighted Average
6,674		40.97% Pervious Area
9,617		59.03% Impervious Area

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

Subcatchment 1 POST: Post 1



Summary for Subcatchment 1 PRE: Pre 1

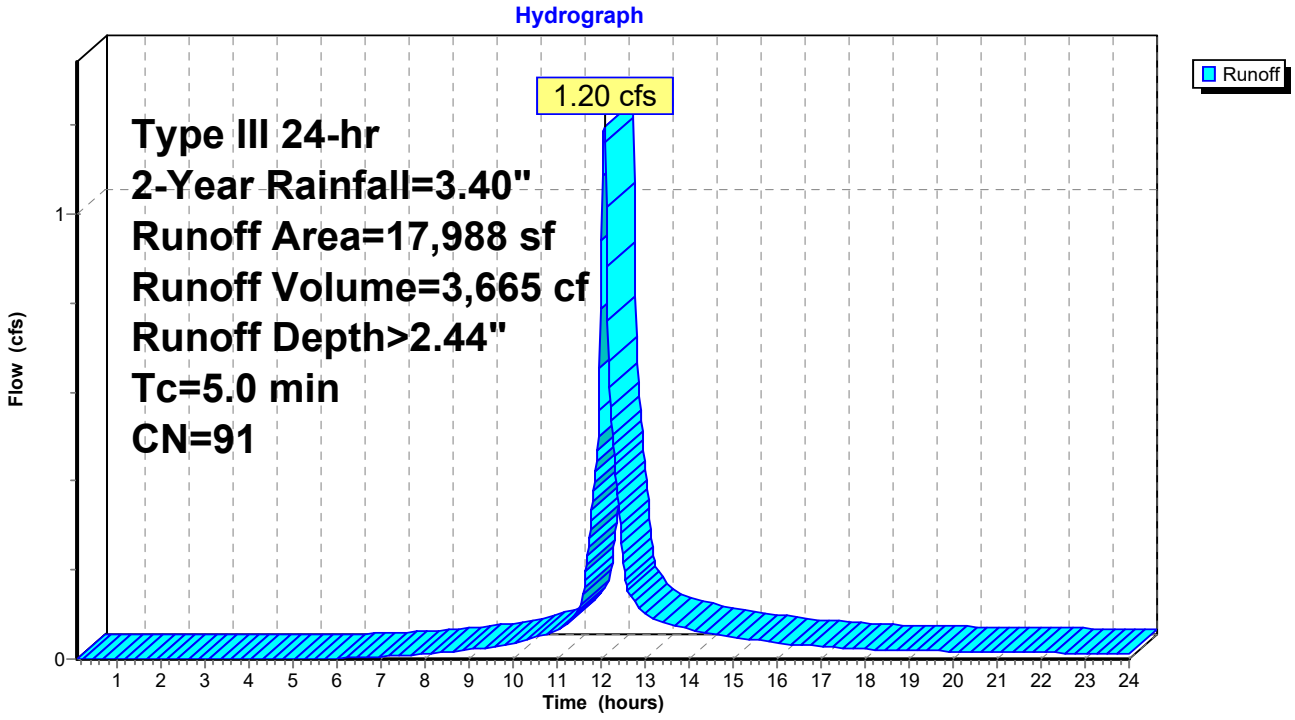
Runoff = 1.20 cfs @ 12.07 hrs, Volume= 3,665 cf, Depth> 2.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,774	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
11,450	98	Paved parking, HSG C
17,988	91	Weighted Average
6,538		36.35% Pervious Area
11,450		63.65% Impervious Area

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

Subcatchment 1 PRE: Pre 1



Summary for Subcatchment 2 POST: Post 2

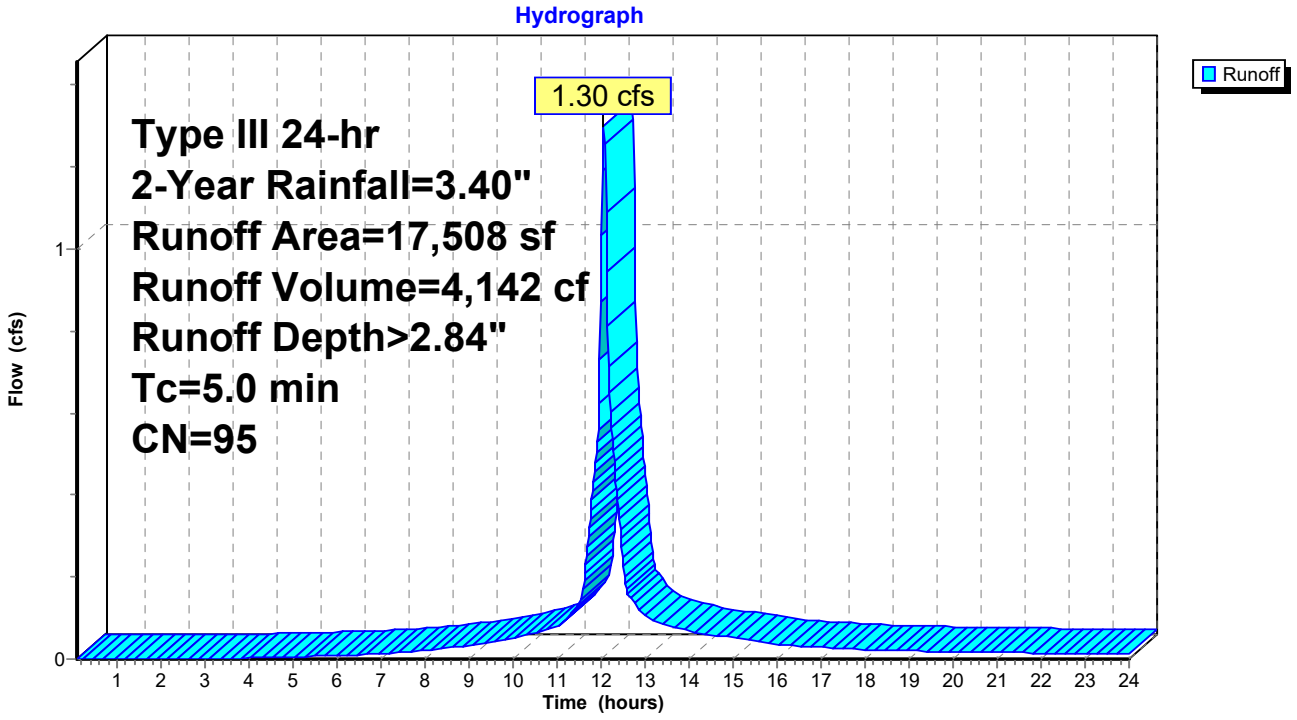
Runoff = 1.30 cfs @ 12.07 hrs, Volume= 4,142 cf, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
1,348	73	Woods, Fair, HSG C
6,831	98	Paved parking, HSG C
9,329	96	Gravel surface, HSG C
17,508	95	Weighted Average
10,677		60.98% Pervious Area
6,831		39.02% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

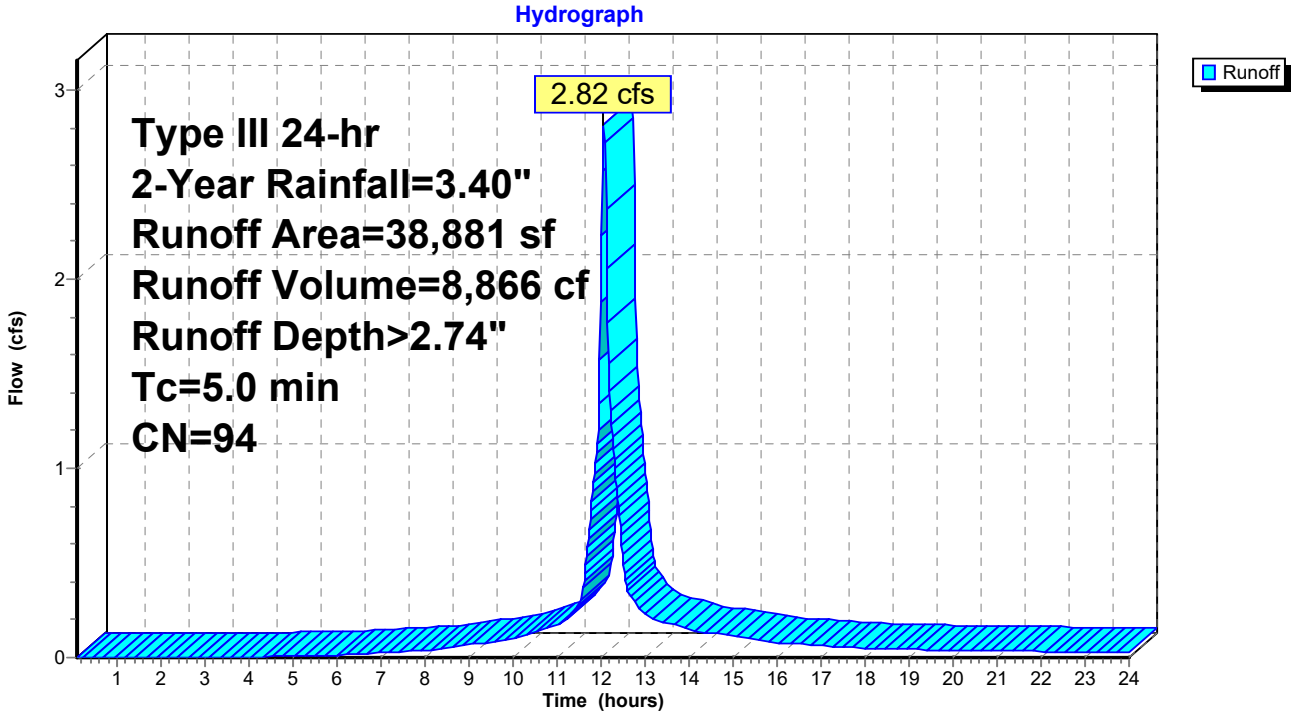
Runoff = 2.82 cfs @ 12.07 hrs, Volume= 8,866 cf, Depth> 2.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
4,958	73	Woods, Fair, HSG C
6,631	98	Roofs, HSG C
13,977	98	Paved parking, HSG C
13,315	96	Gravel surface, HSG C
38,881	94	Weighted Average
18,273		47.00% Pervious Area
20,608		53.00% Impervious Area

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

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

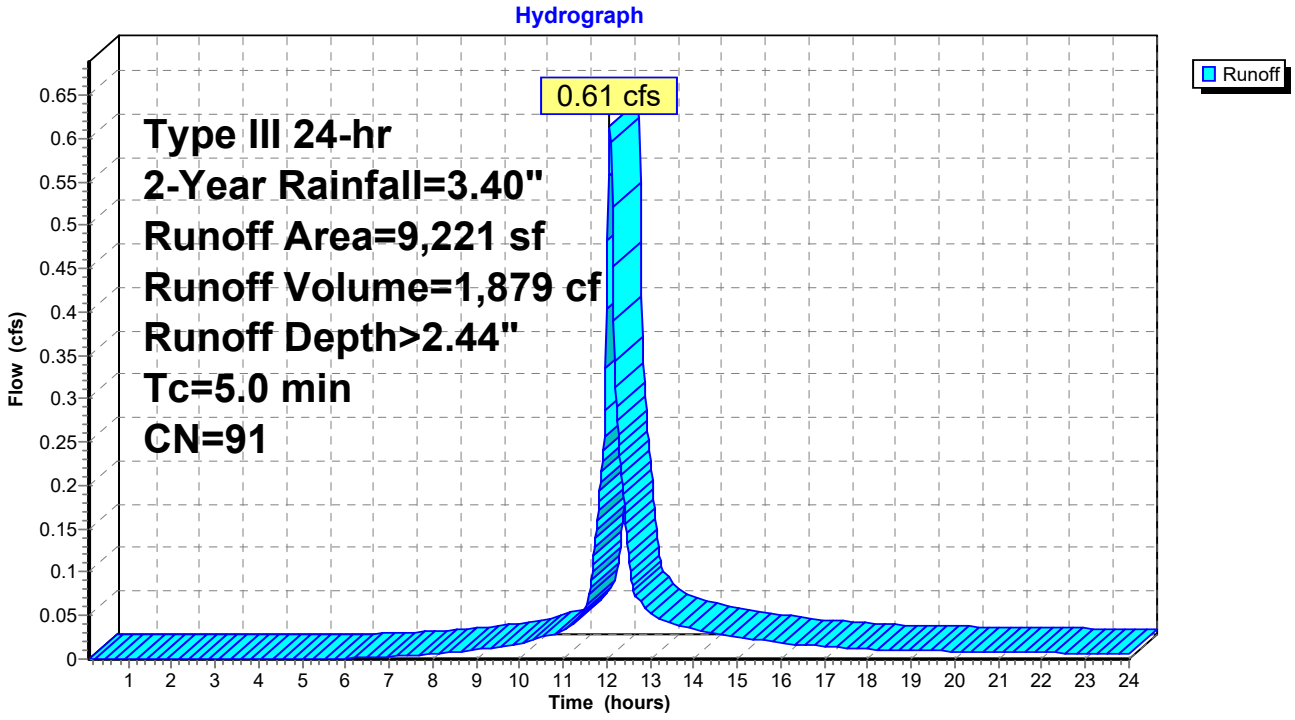
Runoff = 0.61 cfs @ 12.07 hrs, Volume= 1,879 cf, Depth> 2.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

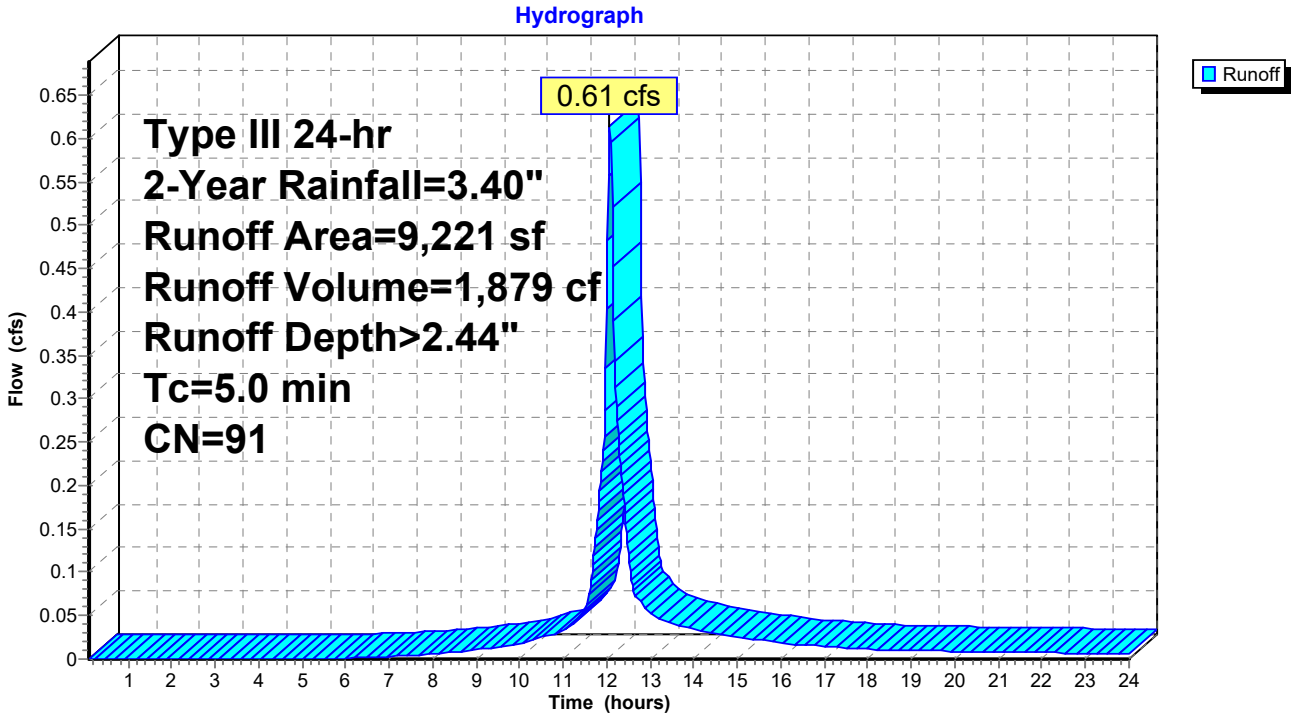
Runoff = 0.61 cfs @ 12.07 hrs, Volume= 1,879 cf, Depth> 2.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

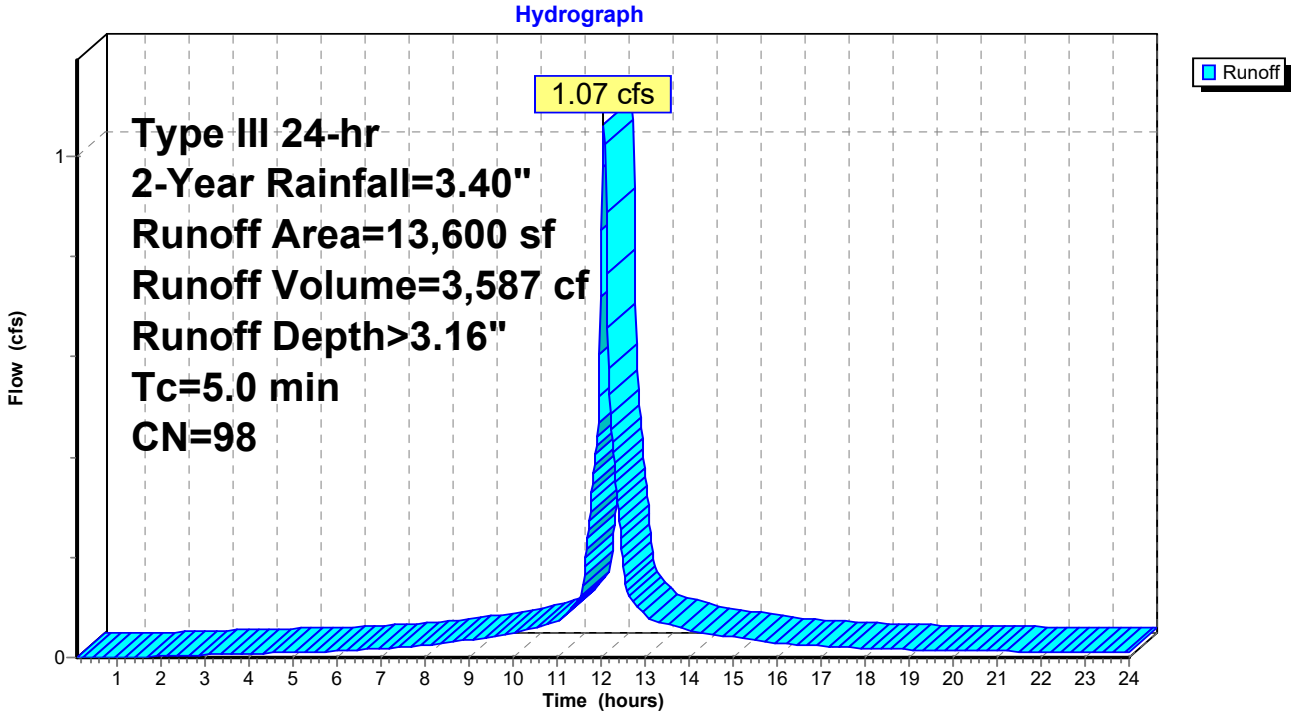
Runoff = 1.07 cfs @ 12.07 hrs, Volume= 3,587 cf, Depth> 3.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
13,600	98	Unconnected roofs, HSG C
13,600		100.00% Impervious Area
13,600		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

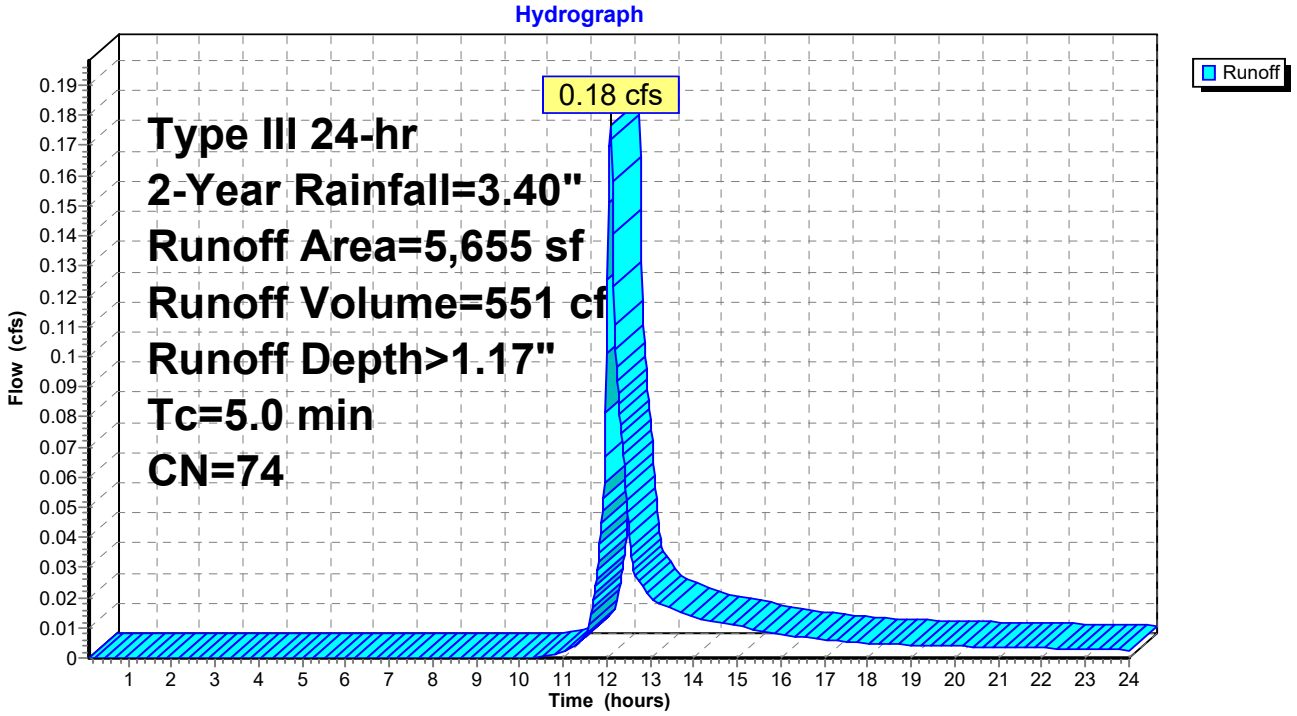
Runoff = 0.18 cfs @ 12.08 hrs, Volume= 551 cf, Depth> 1.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
5,655	74	>75% Grass cover, Good, HSG C
5,655		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Subcatchment 6 POST: Post 6

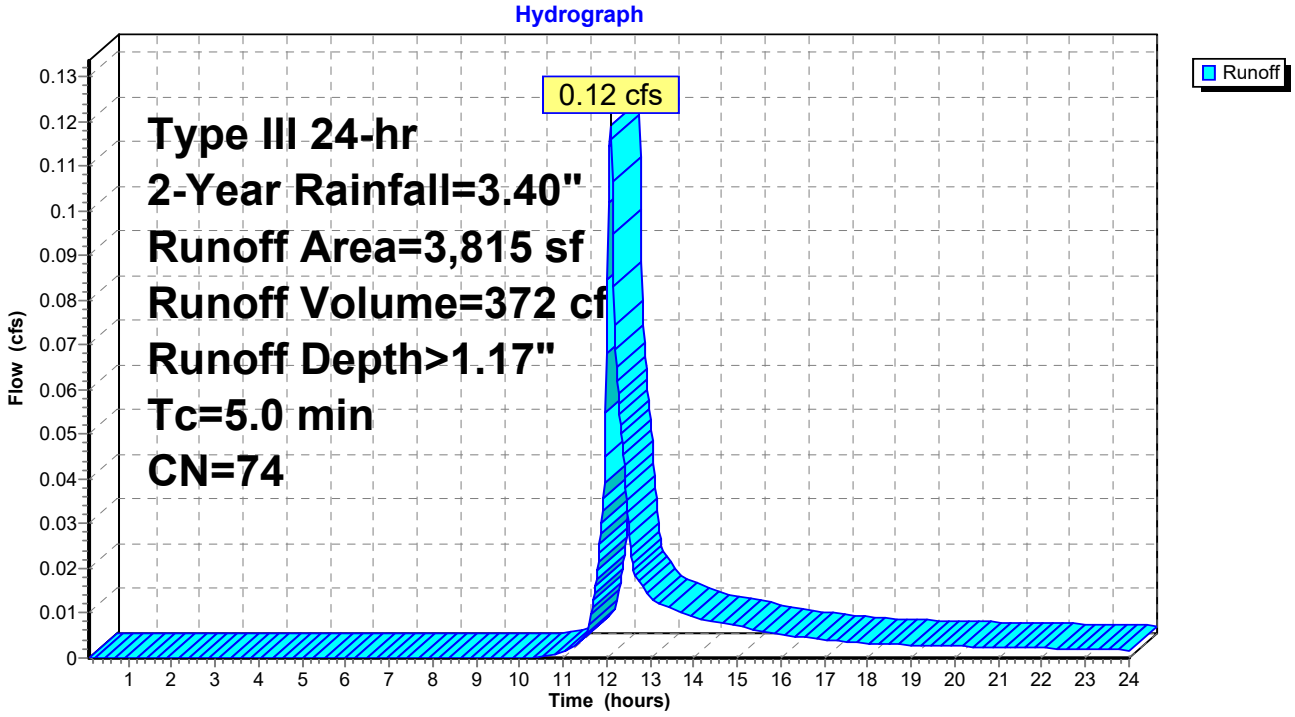
Runoff = 0.12 cfs @ 12.08 hrs, Volume= 372 cf, Depth> 1.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 2-Year Rainfall=3.40"

Area (sf)	CN	Description
949	79	50-75% Grass cover, Fair, HSG C
2,866	73	Woods, Fair, HSG C
3,815	74	Weighted Average
3,815		100.00% Pervious Area

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

Subcatchment 6 POST: Post 6



Summary for Pond 7R: Rain Garden

Inflow Area = 19,255 sf, 70.63% Impervious, Inflow Depth > 2.58" for 2-Year event
Inflow = 1.24 cfs @ 12.07 hrs, Volume= 4,138 cf
Outflow = 0.90 cfs @ 12.14 hrs, Volume= 2,472 cf, Atten= 27%, Lag= 4.3 min
Primary = 0.90 cfs @ 12.14 hrs, Volume= 2,472 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 197.59' @ 12.14 hrs Surf.Area= 2,148 sf Storage= 1,852 cf

Plug-Flow detention time= 214.6 min calculated for 2,472 cf (60% of inflow)
Center-of-Mass det. time= 103.6 min (871.1 - 767.5)

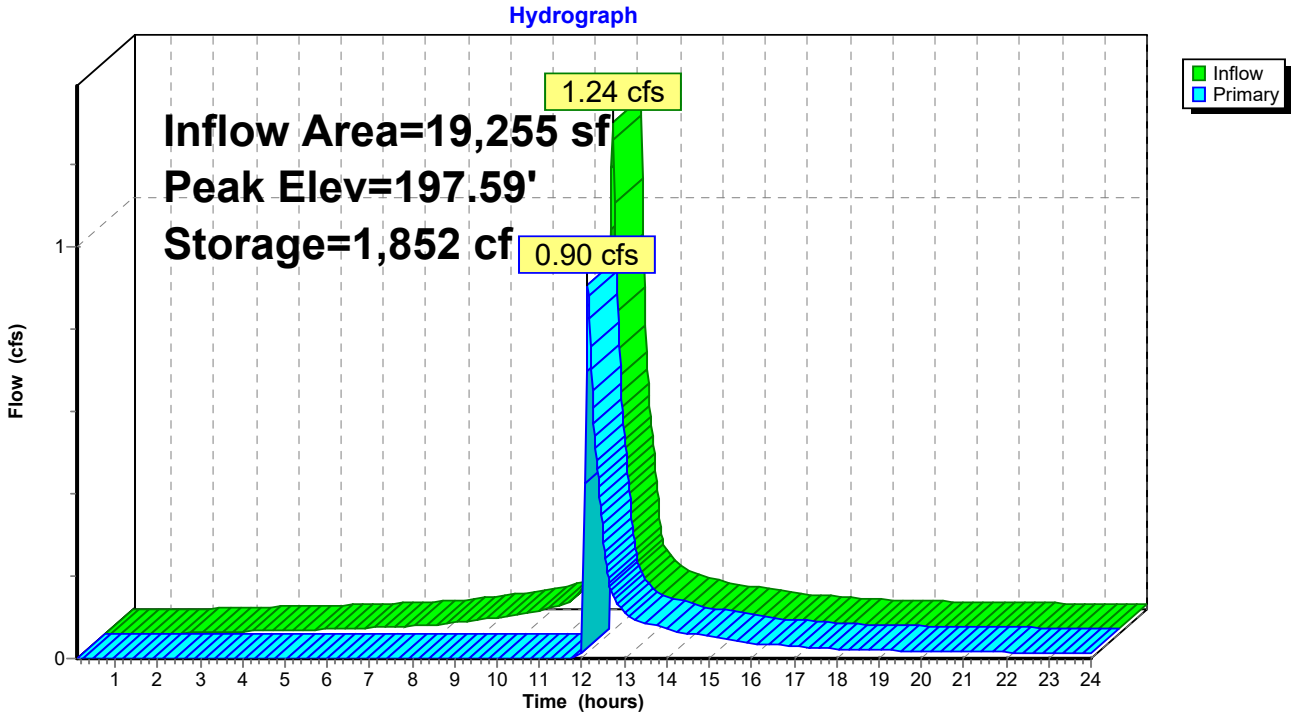
Volume	Invert	Avail.Storage	Storage Description
#1	196.00'	2,838 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
196.00	231	0	0
197.00	1,384	808	808
198.00	2,676	2,030	2,838

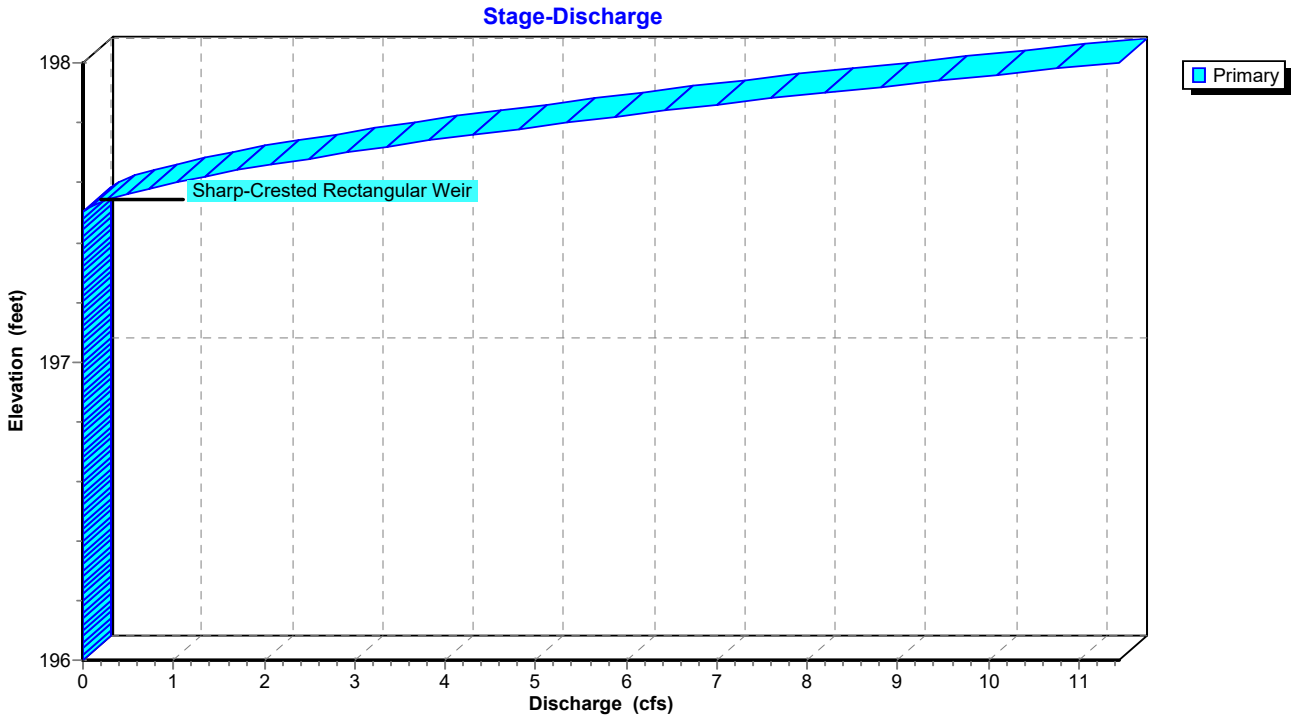
Device	Routing	Invert	Outlet Devices
#1	Primary	197.50'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=0.89 cfs @ 12.14 hrs HW=197.59' (Free Discharge)
↑—**1=Sharp-Crested Rectangular Weir** (Weir Controls 0.89 cfs @ 0.99 fps)

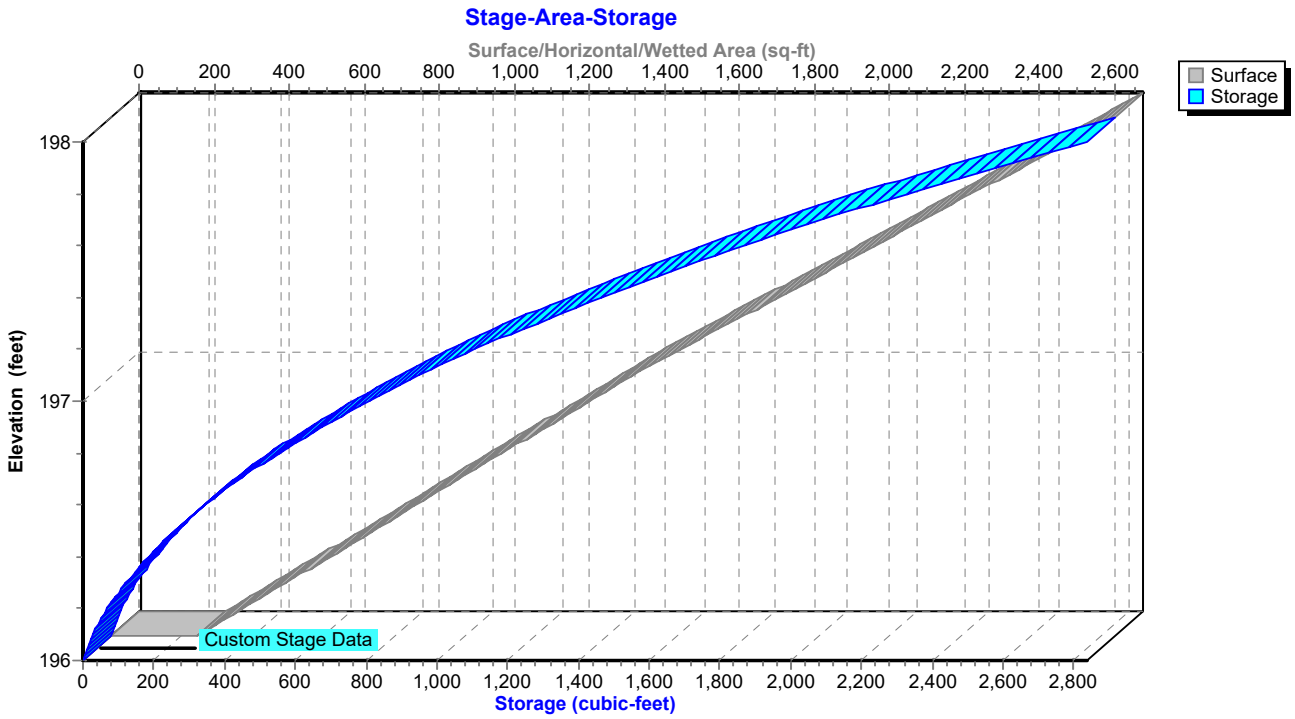
Pond 7R: Rain Garden



Pond 7R: Rain Garden



Pond 7R: Rain Garden

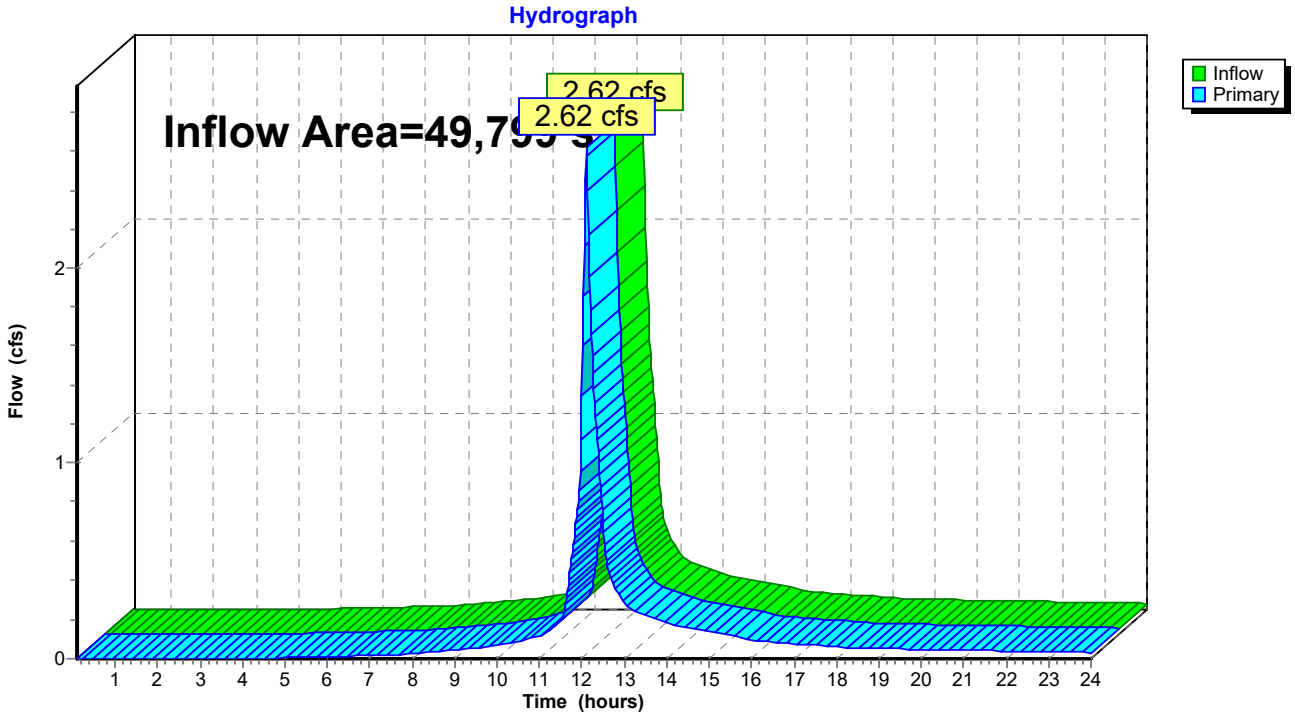


Summary for Link 8L: North West/East Wetland

Inflow Area = 49,799 sf, 43.39% Impervious, Inflow Depth > 2.14" for 2-Year event
Inflow = 2.62 cfs @ 12.11 hrs, Volume= 8,865 cf
Primary = 2.62 cfs @ 12.11 hrs, Volume= 8,865 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 8L: North West/East Wetland

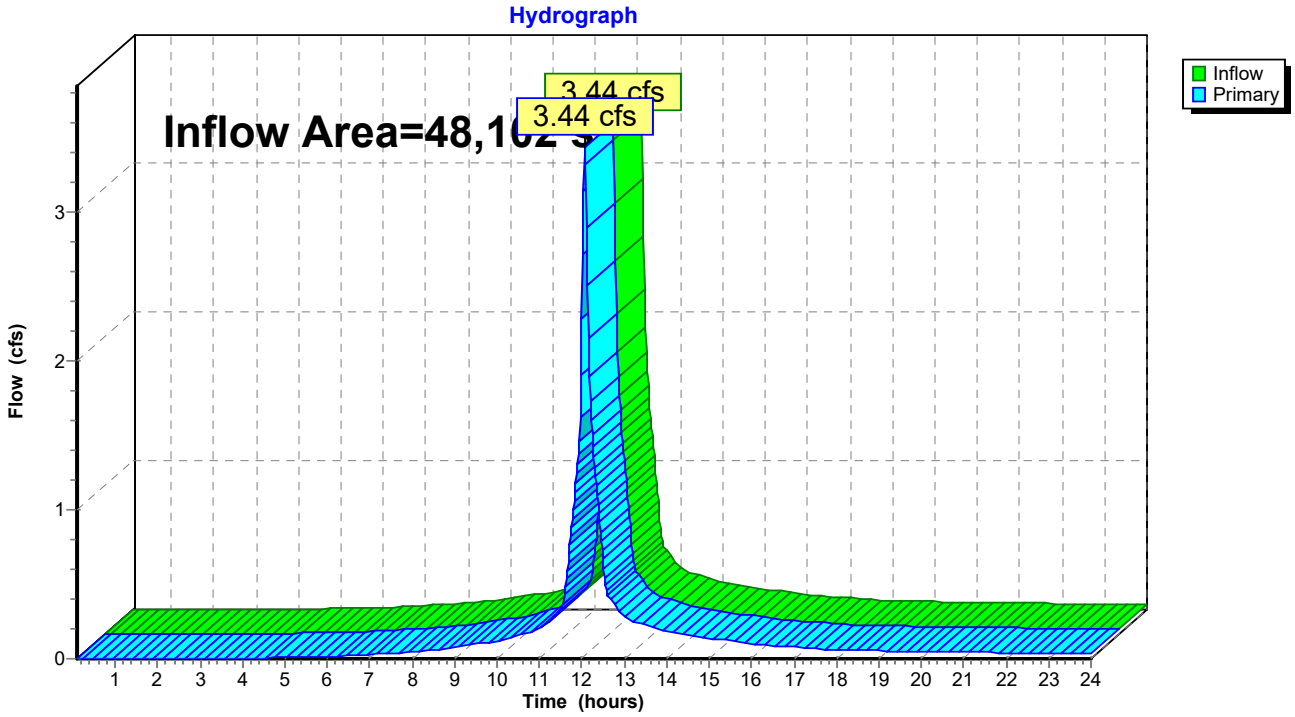


Summary for Link 9L: North West/East Wetland

Inflow Area = 48,102 sf, 45.29% Impervious, Inflow Depth > 2.68" for 2-Year event
Inflow = 3.44 cfs @ 12.07 hrs, Volume= 10,744 cf
Primary = 3.44 cfs @ 12.07 hrs, Volume= 10,744 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 9L: North West/East Wetland



Time span=0.10-24.00 hrs, dt=0.02 hrs, 1196 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1 POST: Post 1	Runoff Area=16,291 sf 59.03% Impervious Runoff Depth>3.58" Tc=5.0 min CN=90 Runoff=1.57 cfs 4,867 cf
Subcatchment 1 PRE: Pre 1	Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>3.69" Tc=5.0 min CN=91 Runoff=1.77 cfs 5,529 cf
Subcatchment 2 POST: Post 2	Runoff Area=17,508 sf 39.02% Impervious Runoff Depth>4.12" Tc=5.0 min CN=95 Runoff=1.85 cfs 6,011 cf
Subcatchment 2 PRE: Pre 2	Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>4.01" Tc=5.0 min CN=94 Runoff=4.05 cfs 12,991 cf
Subcatchment 3 Post: Post 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>3.69" Tc=5.0 min CN=91 Runoff=0.91 cfs 2,834 cf
Subcatchment 3 PRE: Pre 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>3.69" Tc=5.0 min CN=91 Runoff=0.91 cfs 2,834 cf
Subcatchment 4 POST: Post 4	Runoff Area=13,600 sf 100.00% Impervious Runoff Depth>4.46" Tc=5.0 min CN=98 Runoff=1.48 cfs 5,056 cf
Subcatchment 5 POST: Post 5	Runoff Area=5,655 sf 0.00% Impervious Runoff Depth>2.13" Tc=5.0 min CN=74 Runoff=0.33 cfs 1,002 cf
Subcatchment 6 POST: Post 6	Runoff Area=3,815 sf 0.00% Impervious Runoff Depth>2.13" Tc=5.0 min CN=74 Runoff=0.22 cfs 676 cf
Pond 7R: Rain Garden	Peak Elev=197.64' Storage=1,954 cf Inflow=1.81 cfs 6,057 cf Outflow=1.68 cfs 4,389 cf
Link 8L: North West/East Wetland	Inflow=4.58 cfs 13,910 cf Primary=4.58 cfs 13,910 cf
Link 9L: North West/East Wetland	Inflow=4.96 cfs 15,826 cf Primary=4.96 cfs 15,826 cf

Total Runoff Area = 132,180 sf Runoff Volume = 41,800 cf Average Runoff Depth = 3.79"
51.23% Pervious = 67,720 sf 48.77% Impervious = 64,460 sf

Summary for Subcatchment 1 POST: Post 1

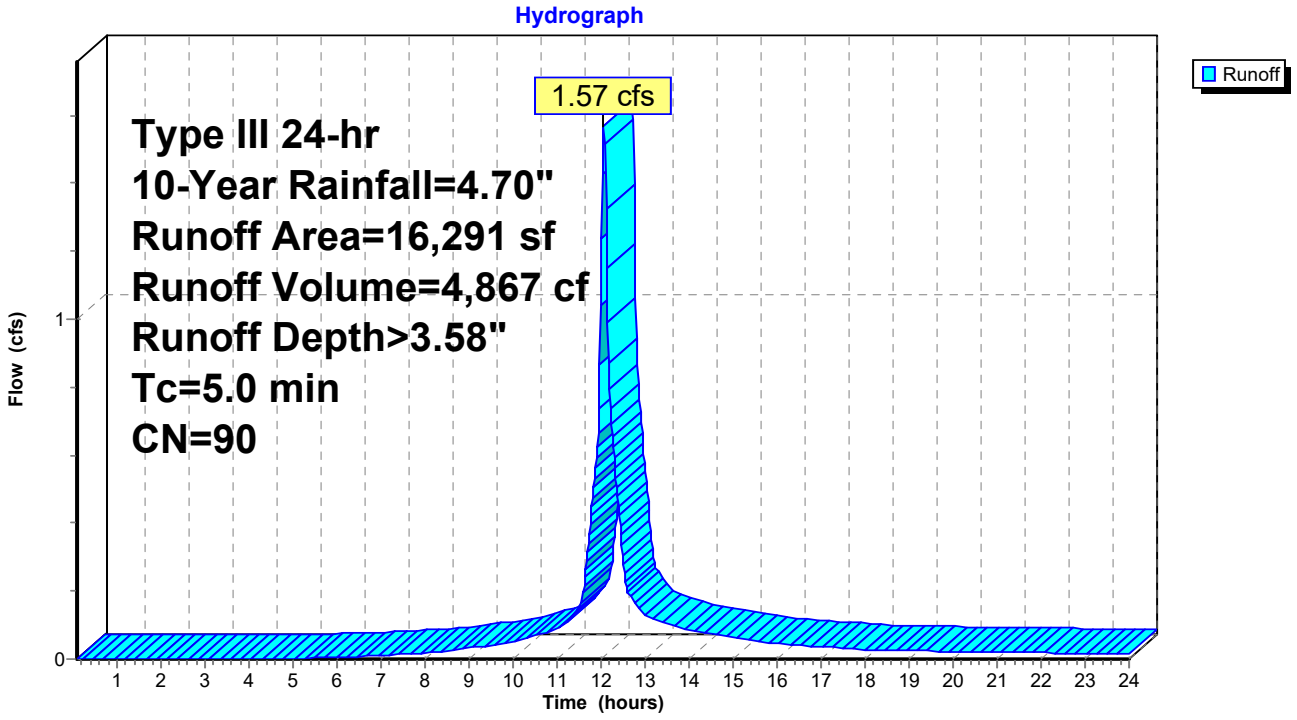
Runoff = 1.57 cfs @ 12.07 hrs, Volume= 4,867 cf, Depth> 3.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,910	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
9,617	98	Paved parking, HSG C
16,291	90	Weighted Average
6,674		40.97% Pervious Area
9,617		59.03% Impervious Area

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

Subcatchment 1 POST: Post 1



Summary for Subcatchment 1 PRE: Pre 1

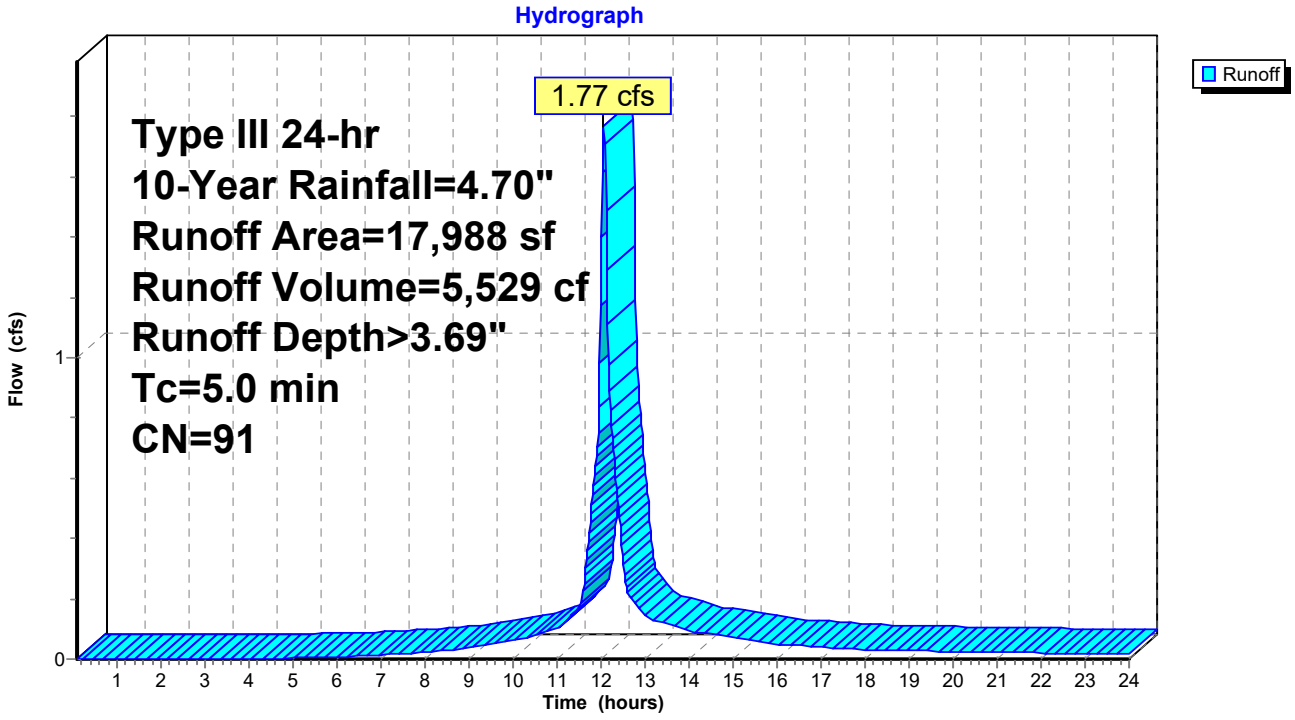
Runoff = 1.77 cfs @ 12.07 hrs, Volume= 5,529 cf, Depth> 3.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,774	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
11,450	98	Paved parking, HSG C
17,988	91	Weighted Average
6,538		36.35% Pervious Area
11,450		63.65% Impervious Area

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

Subcatchment 1 PRE: Pre 1



Summary for Subcatchment 2 POST: Post 2

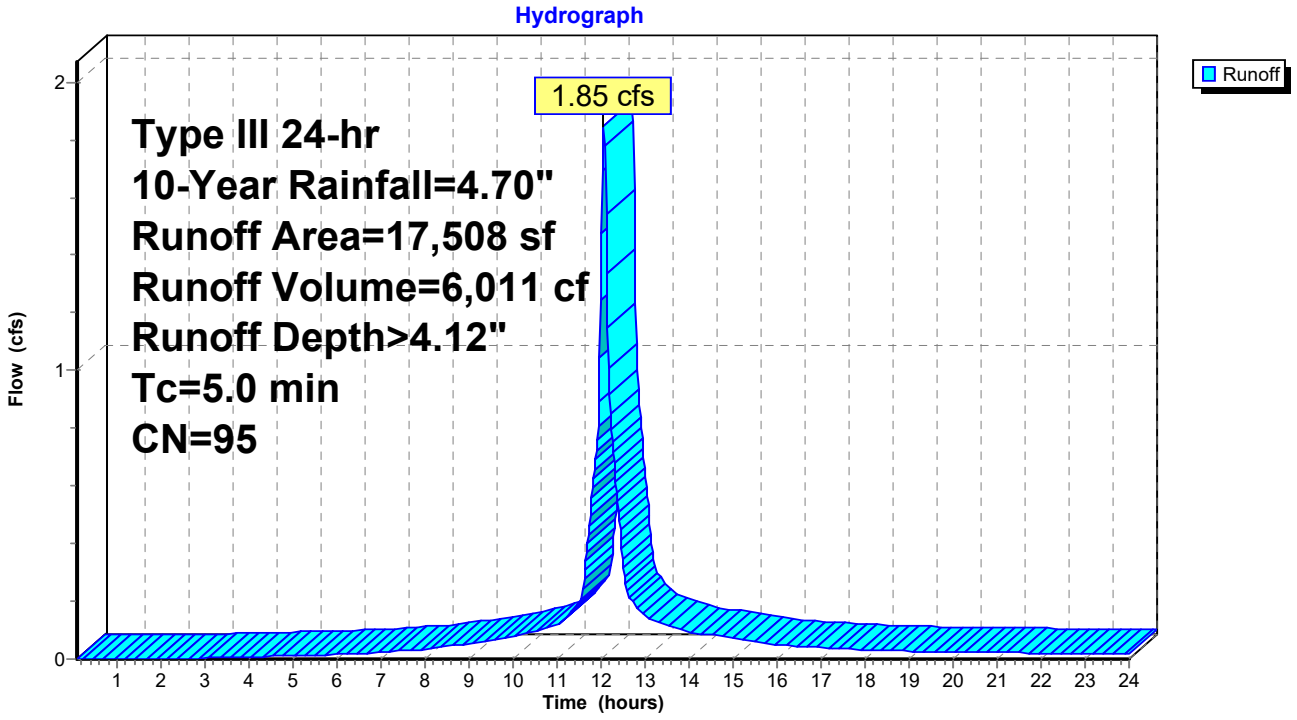
Runoff = 1.85 cfs @ 12.07 hrs, Volume= 6,011 cf, Depth> 4.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
1,348	73	Woods, Fair, HSG C
6,831	98	Paved parking, HSG C
9,329	96	Gravel surface, HSG C
17,508	95	Weighted Average
10,677		60.98% Pervious Area
6,831		39.02% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

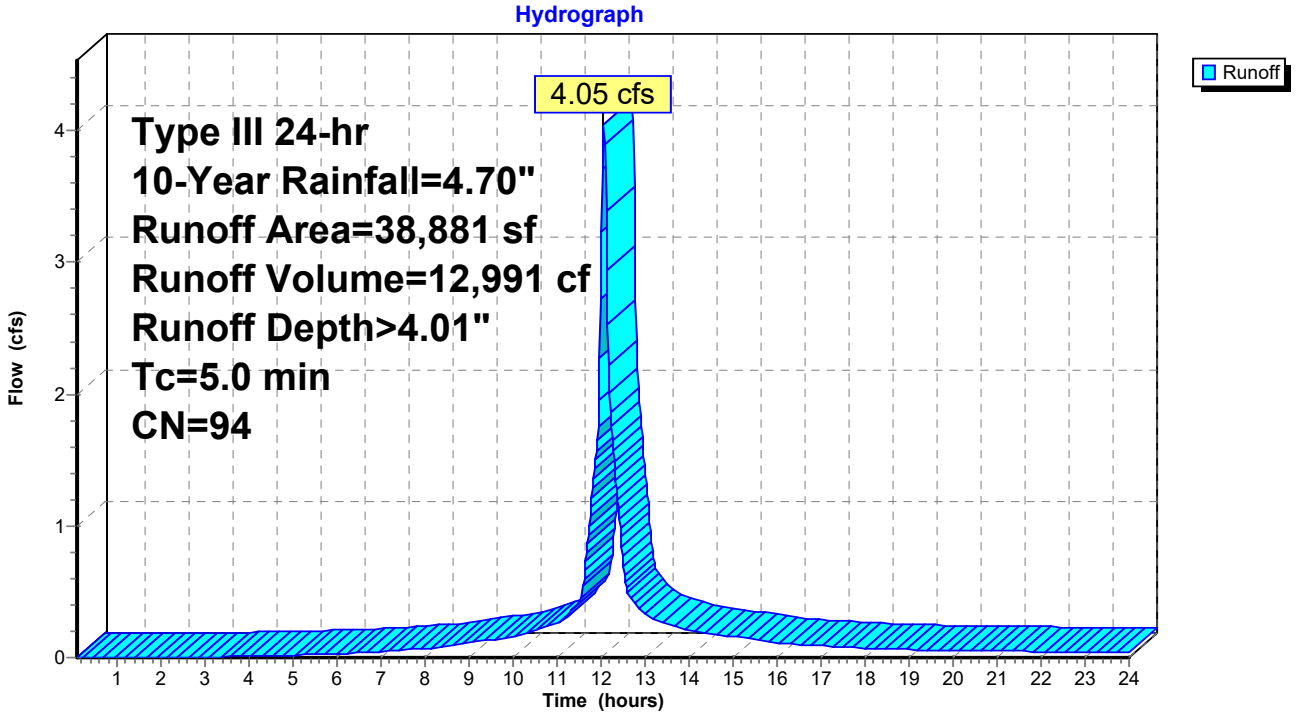
Runoff = 4.05 cfs @ 12.07 hrs, Volume= 12,991 cf, Depth> 4.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
4,958	73	Woods, Fair, HSG C
6,631	98	Roofs, HSG C
13,977	98	Paved parking, HSG C
13,315	96	Gravel surface, HSG C
38,881	94	Weighted Average
18,273		47.00% Pervious Area
20,608		53.00% Impervious Area

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

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

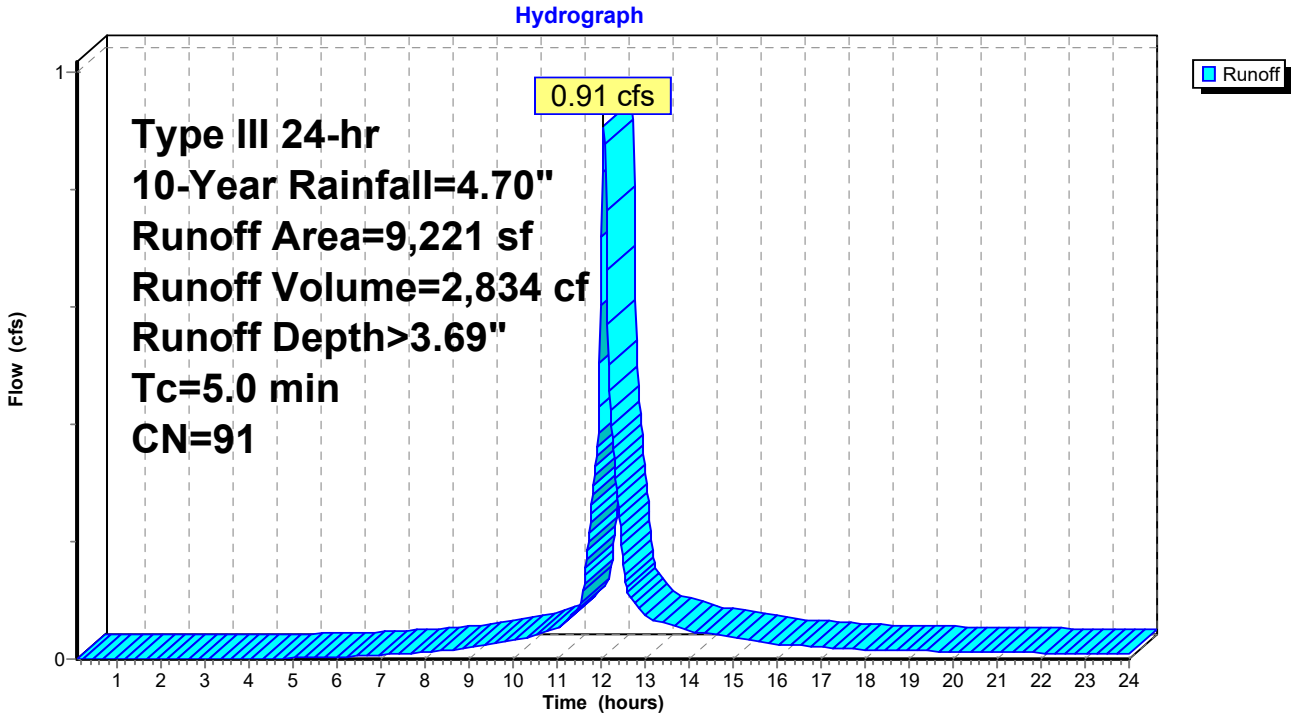
Runoff = 0.91 cfs @ 12.07 hrs, Volume= 2,834 cf, Depth> 3.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

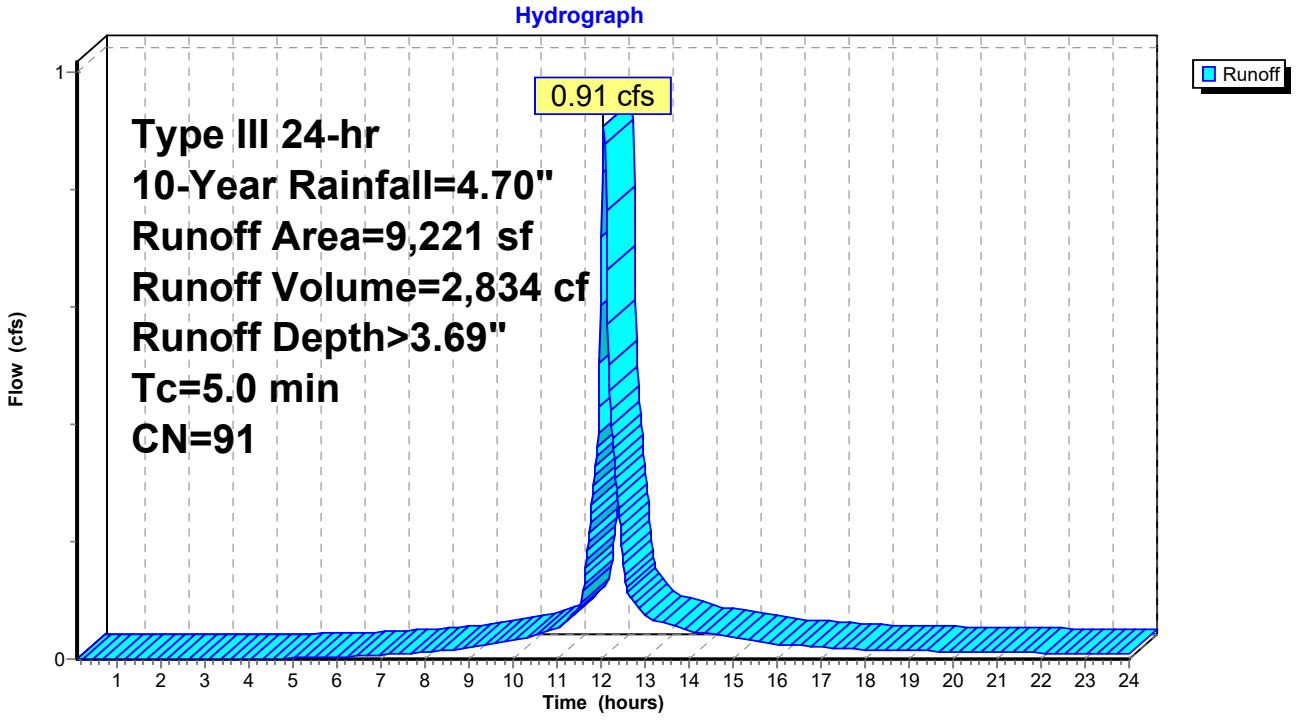
Runoff = 0.91 cfs @ 12.07 hrs, Volume= 2,834 cf, Depth> 3.69"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

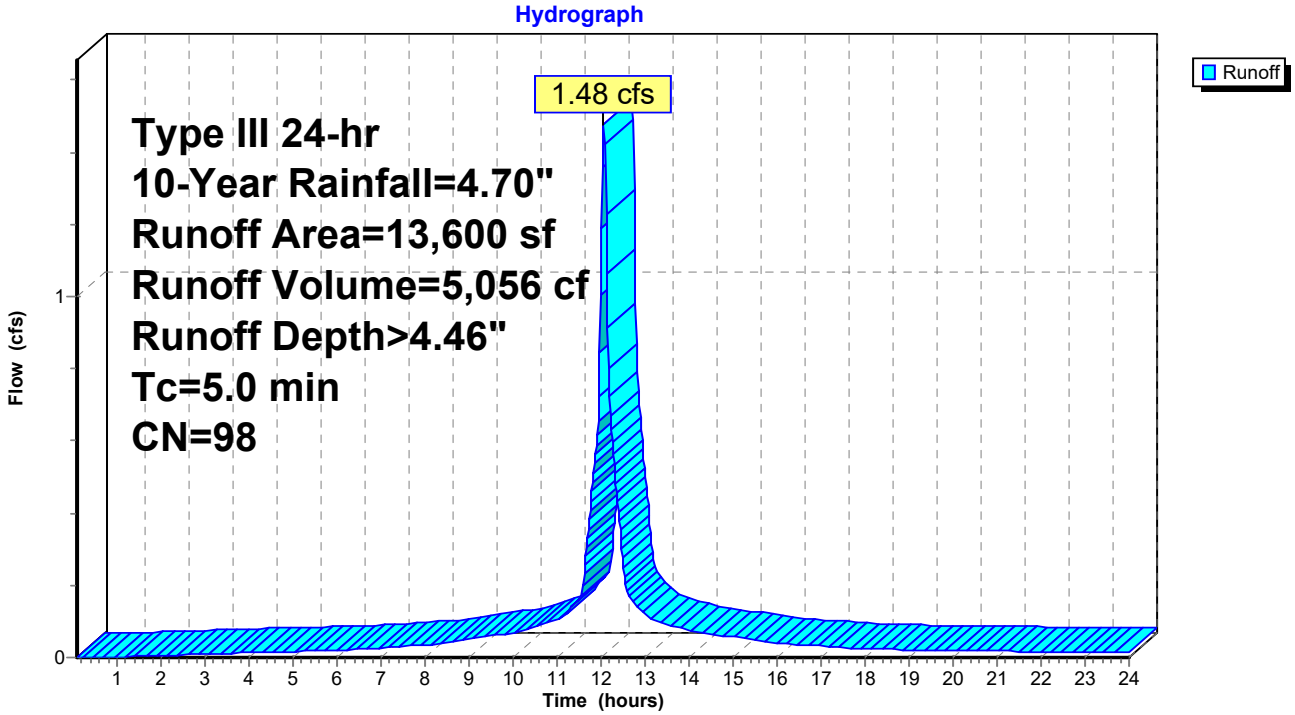
Runoff = 1.48 cfs @ 12.07 hrs, Volume= 5,056 cf, Depth> 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
13,600	98	Unconnected roofs, HSG C
13,600		100.00% Impervious Area
13,600		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

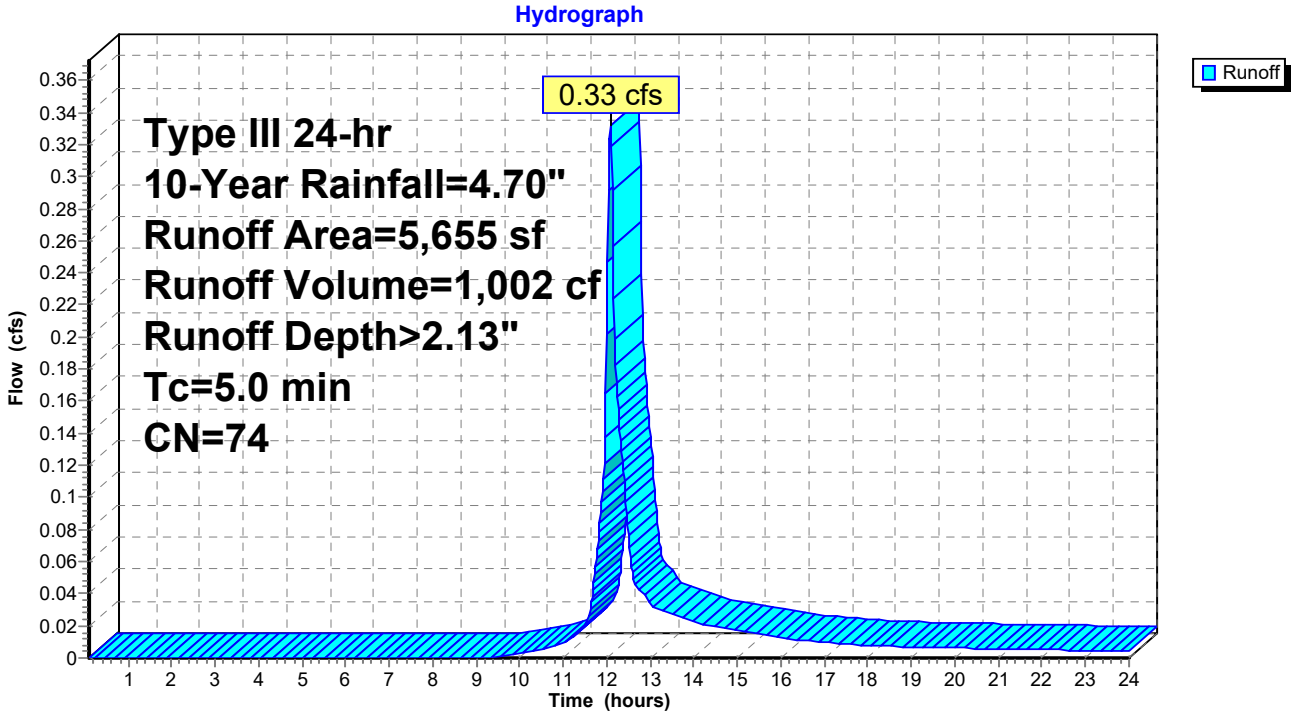
Runoff = 0.33 cfs @ 12.08 hrs, Volume= 1,002 cf, Depth> 2.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
5,655	74	>75% Grass cover, Good, HSG C
5,655		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Subcatchment 6 POST: Post 6

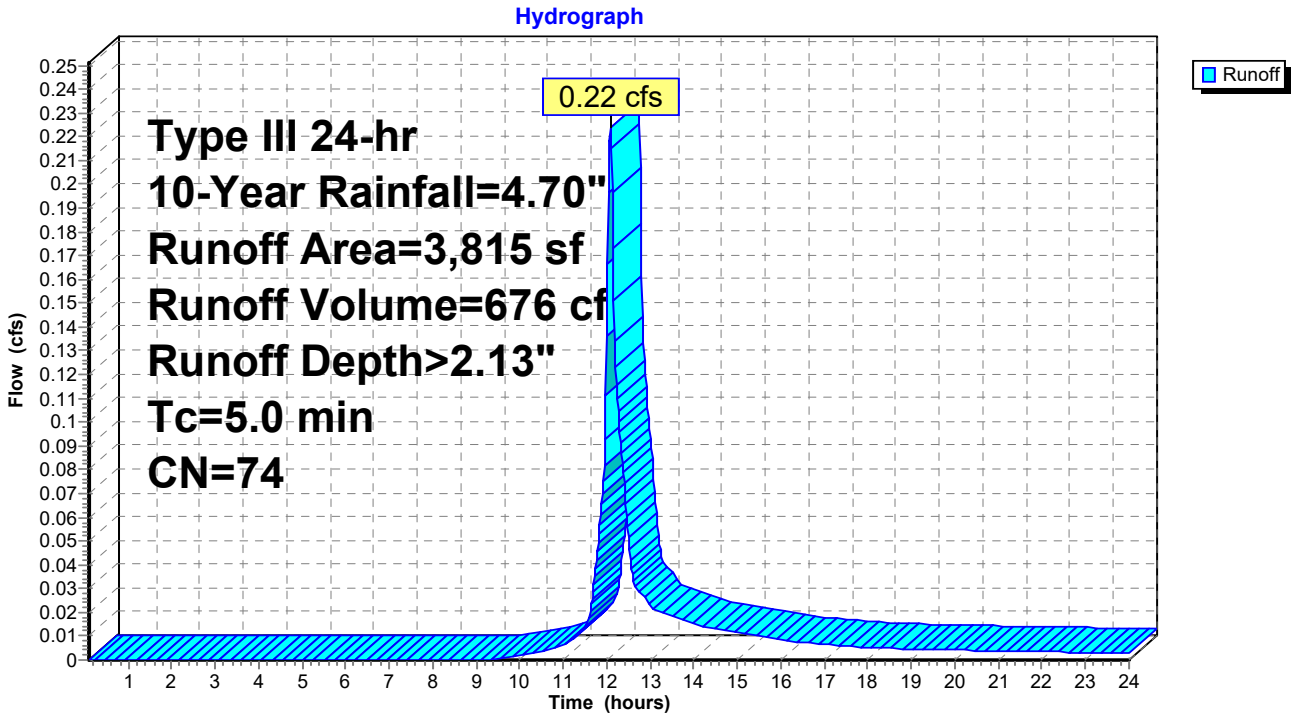
Runoff = 0.22 cfs @ 12.08 hrs, Volume= 676 cf, Depth> 2.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 10-Year Rainfall=4.70"

Area (sf)	CN	Description
949	79	50-75% Grass cover, Fair, HSG C
2,866	73	Woods, Fair, HSG C
3,815	74	Weighted Average
3,815		100.00% Pervious Area

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

Subcatchment 6 POST: Post 6



Summary for Pond 7R: Rain Garden

Inflow Area = 19,255 sf, 70.63% Impervious, Inflow Depth > 3.77" for 10-Year event
Inflow = 1.81 cfs @ 12.07 hrs, Volume= 6,057 cf
Outflow = 1.68 cfs @ 12.10 hrs, Volume= 4,389 cf, Atten= 7%, Lag= 1.9 min
Primary = 1.68 cfs @ 12.10 hrs, Volume= 4,389 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 197.64' @ 12.10 hrs Surf.Area= 2,209 sf Storage= 1,954 cf

Plug-Flow detention time= 171.5 min calculated for 4,389 cf (72% of inflow)
Center-of-Mass det. time= 79.0 min (841.8 - 762.8)

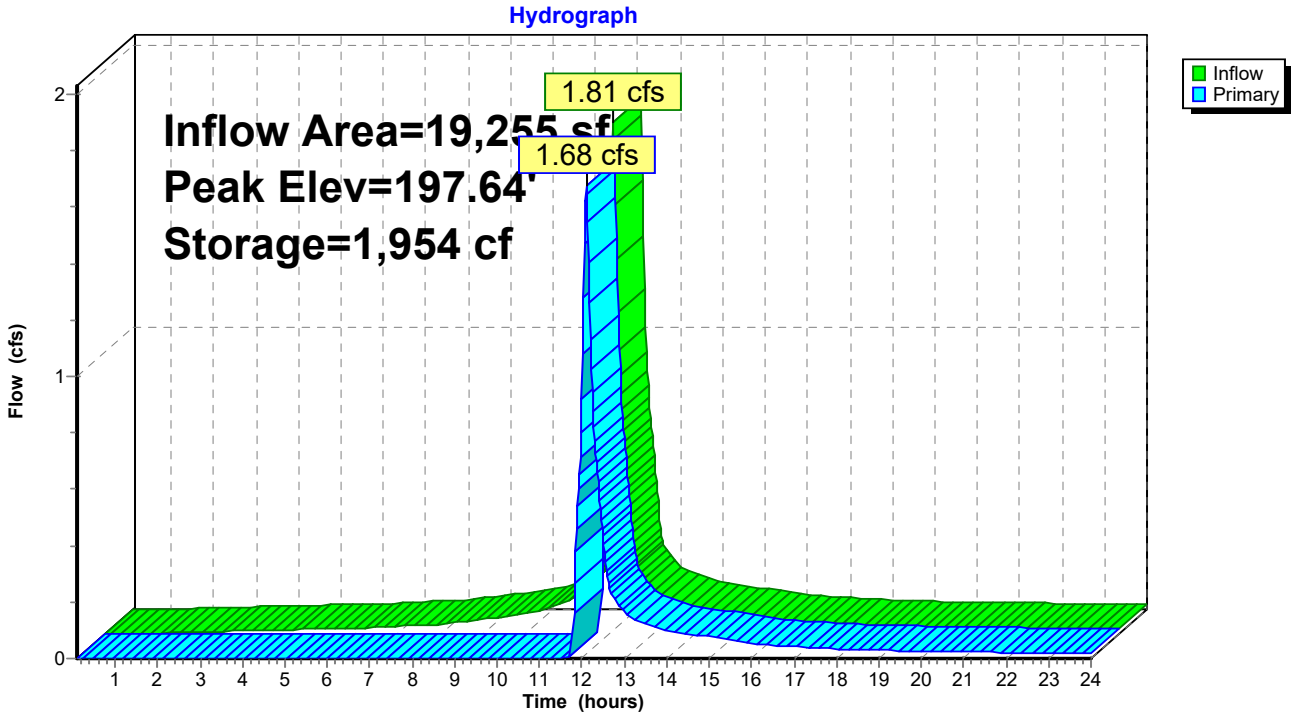
Volume	Invert	Avail.Storage	Storage Description
#1	196.00'	2,838 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
196.00	231	0	0
197.00	1,384	808	808
198.00	2,676	2,030	2,838

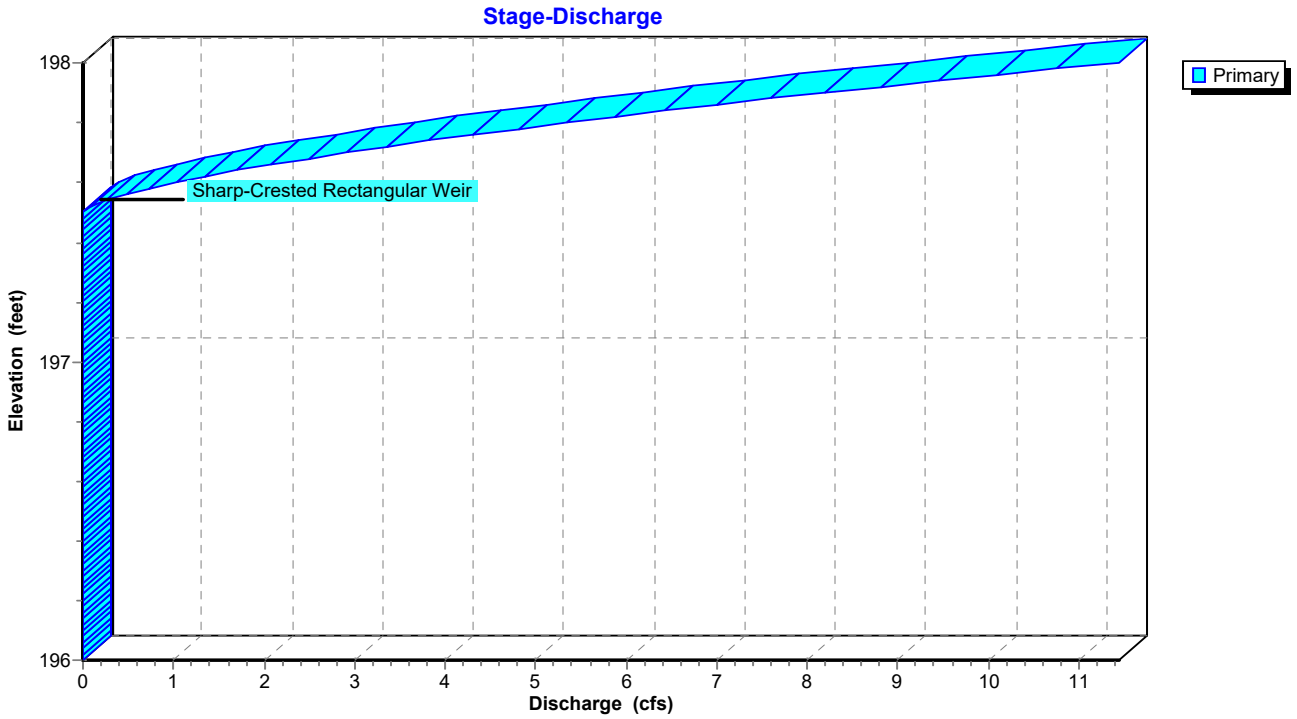
Device	Routing	Invert	Outlet Devices
#1	Primary	197.50'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=1.67 cfs @ 12.10 hrs HW=197.64' (Free Discharge)
↑—**1=Sharp-Crested Rectangular Weir** (Weir Controls 1.67 cfs @ 1.21 fps)

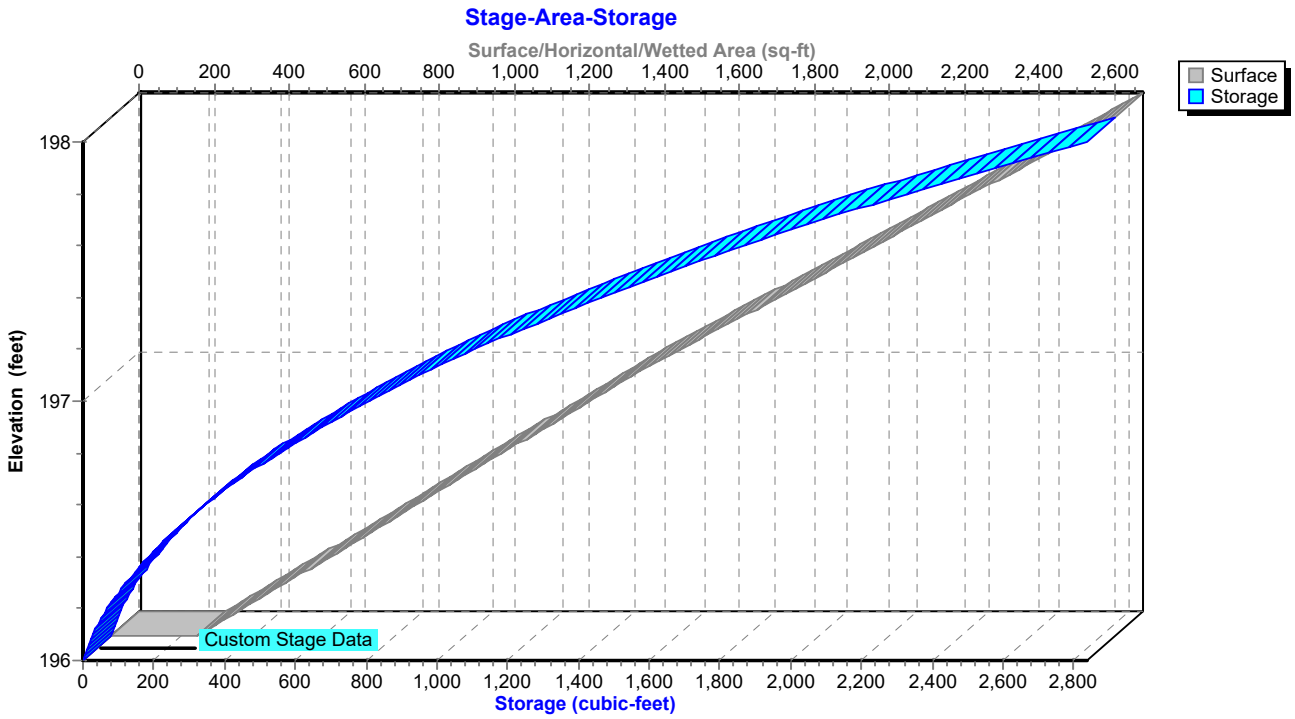
Pond 7R: Rain Garden



Pond 7R: Rain Garden



Pond 7R: Rain Garden

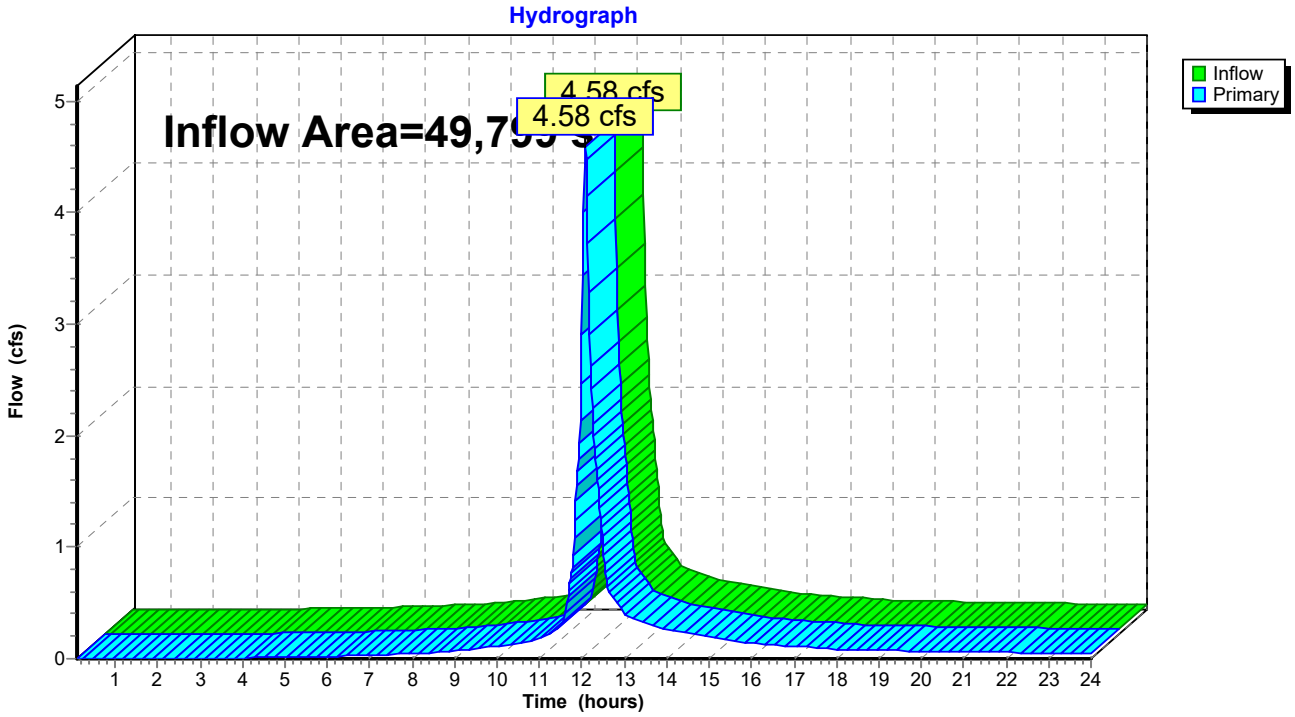


Summary for Link 8L: North West/East Wetland

Inflow Area = 49,799 sf, 43.39% Impervious, Inflow Depth > 3.35" for 10-Year event
Inflow = 4.58 cfs @ 12.08 hrs, Volume= 13,910 cf
Primary = 4.58 cfs @ 12.08 hrs, Volume= 13,910 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 8L: North West/East Wetland

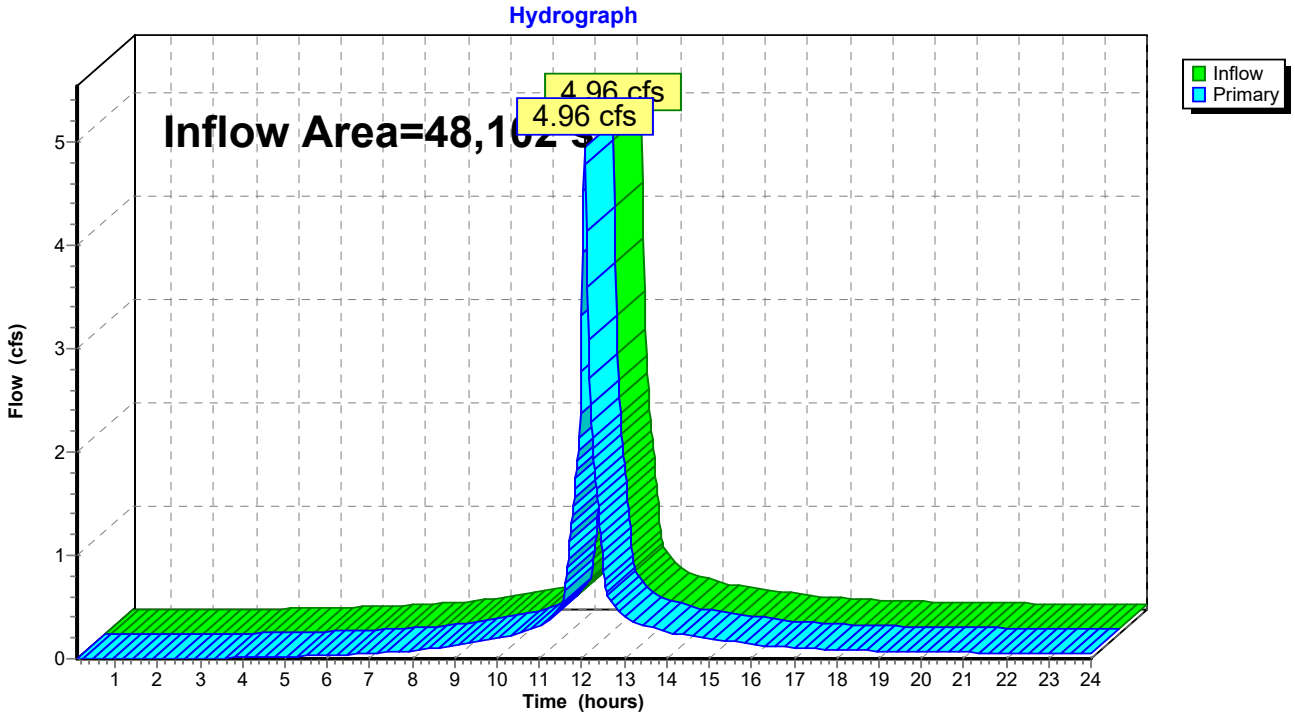


Summary for Link 9L: North West/East Wetland

Inflow Area = 48,102 sf, 45.29% Impervious, Inflow Depth > 3.95" for 10-Year event
Inflow = 4.96 cfs @ 12.07 hrs, Volume= 15,826 cf
Primary = 4.96 cfs @ 12.07 hrs, Volume= 15,826 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 9L: North West/East Wetland



Time span=0.10-24.00 hrs, dt=0.02 hrs, 1196 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1 POST: Post 1	Runoff Area=16,291 sf 59.03% Impervious Runoff Depth>4.45" Tc=5.0 min CN=90 Runoff=1.93 cfs 6,046 cf
Subcatchment 1 PRE: Pre 1	Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>4.56" Tc=5.0 min CN=91 Runoff=2.17 cfs 6,840 cf
Subcatchment 2 POST: Post 2	Runoff Area=17,508 sf 39.02% Impervious Runoff Depth>5.01" Tc=5.0 min CN=95 Runoff=2.22 cfs 7,311 cf
Subcatchment 2 PRE: Pre 2	Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>4.90" Tc=5.0 min CN=94 Runoff=4.89 cfs 15,868 cf
Subcatchment 3 Post: Post 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>4.56" Tc=5.0 min CN=91 Runoff=1.11 cfs 3,506 cf
Subcatchment 3 PRE: Pre 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>4.56" Tc=5.0 min CN=91 Runoff=1.11 cfs 3,506 cf
Subcatchment 4 POST: Post 4	Runoff Area=13,600 sf 100.00% Impervious Runoff Depth>5.36" Tc=5.0 min CN=98 Runoff=1.77 cfs 6,074 cf
Subcatchment 5 POST: Post 5	Runoff Area=5,655 sf 0.00% Impervious Runoff Depth>2.85" Tc=5.0 min CN=74 Runoff=0.45 cfs 1,343 cf
Subcatchment 6 POST: Post 6	Runoff Area=3,815 sf 0.00% Impervious Runoff Depth>2.85" Tc=5.0 min CN=74 Runoff=0.30 cfs 906 cf
Pond 7R: Rain Garden	Peak Elev=197.66' Storage=2,000 cf Inflow=2.21 cfs 7,416 cf Outflow=2.07 cfs 5,746 cf
Link 8L: North West/East Wetland	Inflow=5.62 cfs 17,470 cf Primary=5.62 cfs 17,470 cf
Link 9L: North West/East Wetland	Inflow=6.00 cfs 19,375 cf Primary=6.00 cfs 19,375 cf

Total Runoff Area = 132,180 sf Runoff Volume = 51,401 cf Average Runoff Depth = 4.67"
51.23% Pervious = 67,720 sf 48.77% Impervious = 64,460 sf

Summary for Subcatchment 1 POST: Post 1

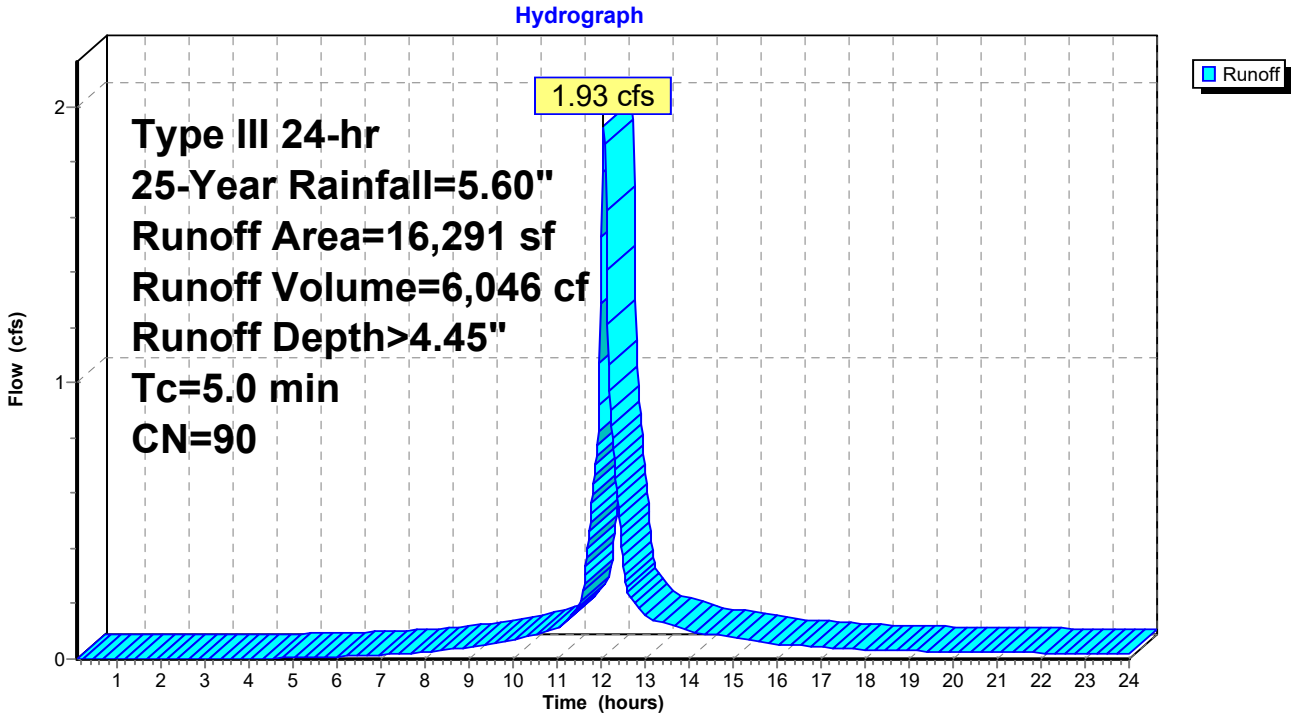
Runoff = 1.93 cfs @ 12.07 hrs, Volume= 6,046 cf, Depth> 4.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
5,910	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
9,617	98	Paved parking, HSG C
16,291	90	Weighted Average
6,674		40.97% Pervious Area
9,617		59.03% Impervious Area

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

Subcatchment 1 POST: Post 1



Summary for Subcatchment 1 PRE: Pre 1

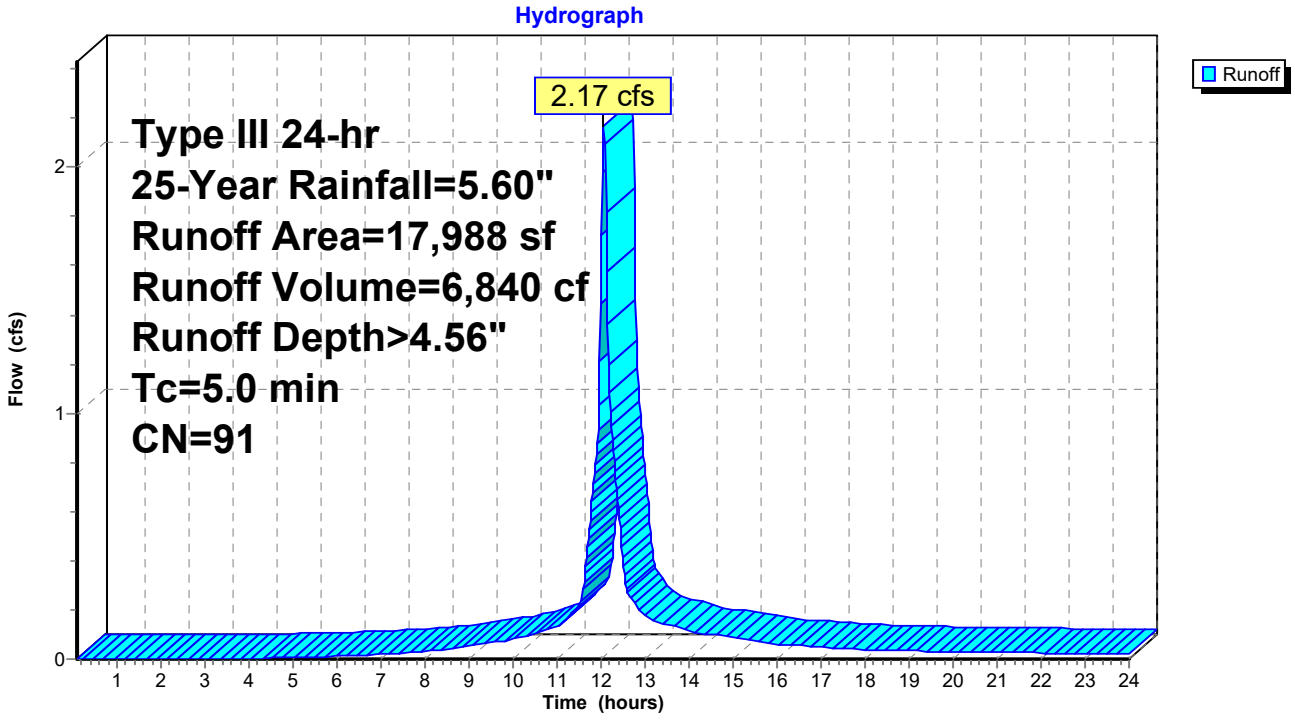
Runoff = 2.17 cfs @ 12.07 hrs, Volume= 6,840 cf, Depth> 4.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
5,774	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
11,450	98	Paved parking, HSG C
17,988	91	Weighted Average
6,538		36.35% Pervious Area
11,450		63.65% Impervious Area

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

Subcatchment 1 PRE: Pre 1



Summary for Subcatchment 2 POST: Post 2

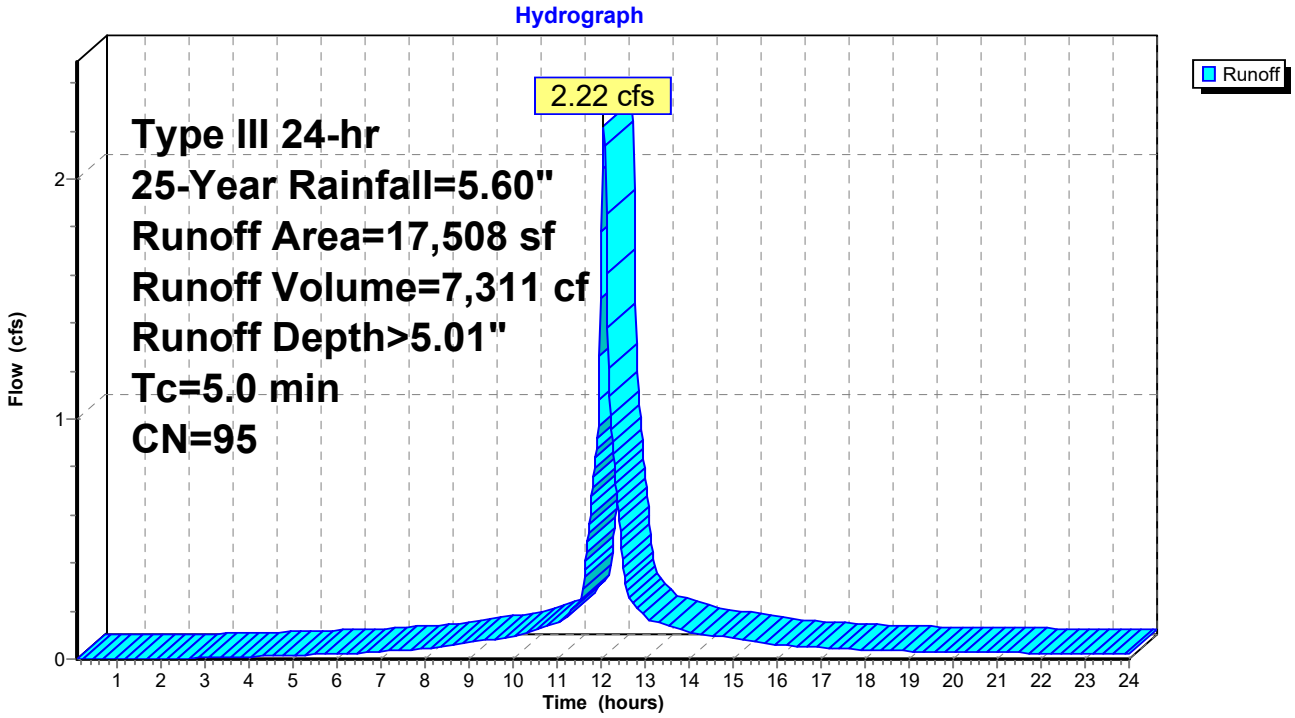
Runoff = 2.22 cfs @ 12.07 hrs, Volume= 7,311 cf, Depth> 5.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
1,348	73	Woods, Fair, HSG C
6,831	98	Paved parking, HSG C
9,329	96	Gravel surface, HSG C
17,508	95	Weighted Average
10,677		60.98% Pervious Area
6,831		39.02% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

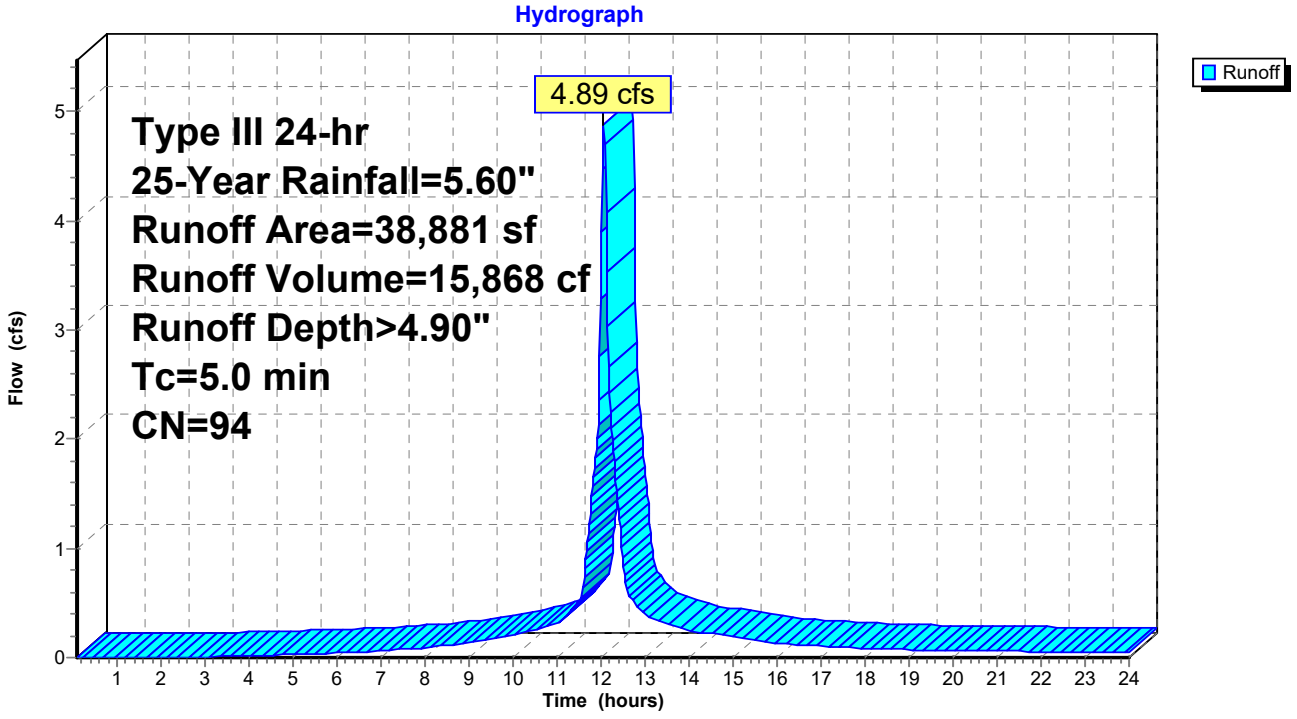
Runoff = 4.89 cfs @ 12.07 hrs, Volume= 15,868 cf, Depth> 4.90"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
4,958	73	Woods, Fair, HSG C
6,631	98	Roofs, HSG C
13,977	98	Paved parking, HSG C
13,315	96	Gravel surface, HSG C
38,881	94	Weighted Average
18,273		47.00% Pervious Area
20,608		53.00% Impervious Area

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

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

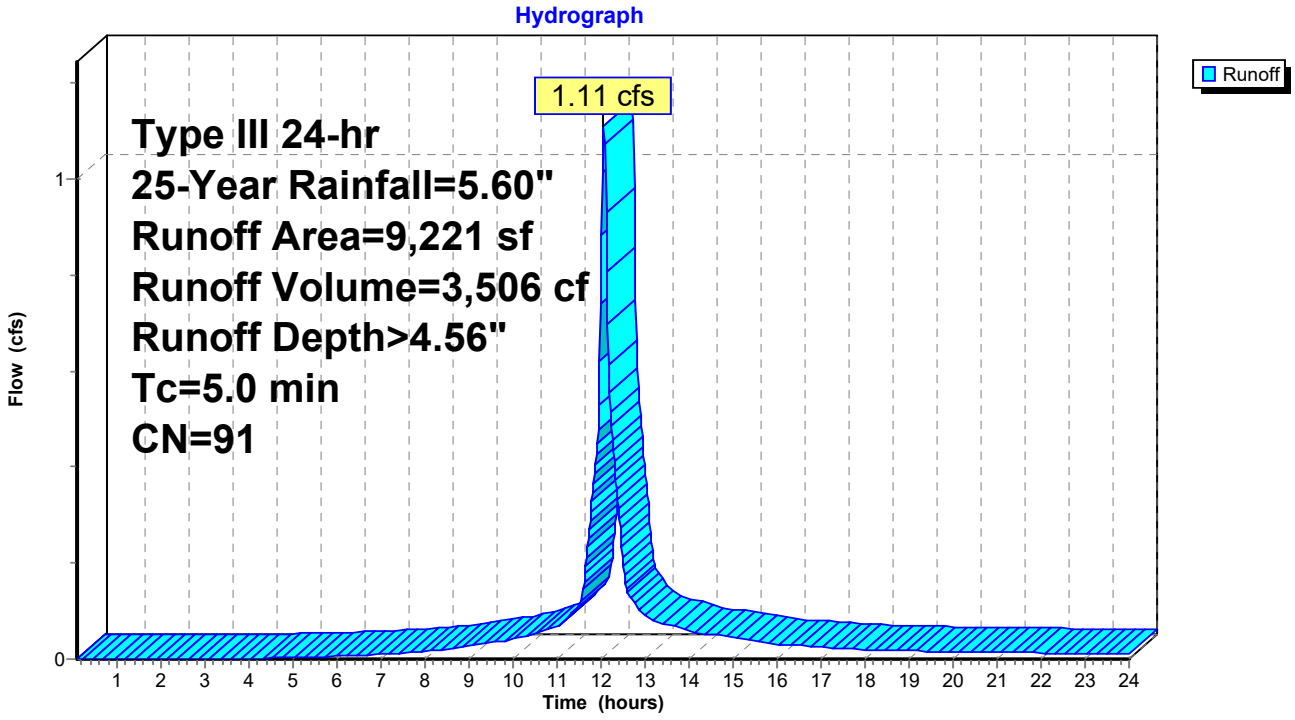
Runoff = 1.11 cfs @ 12.07 hrs, Volume= 3,506 cf, Depth> 4.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

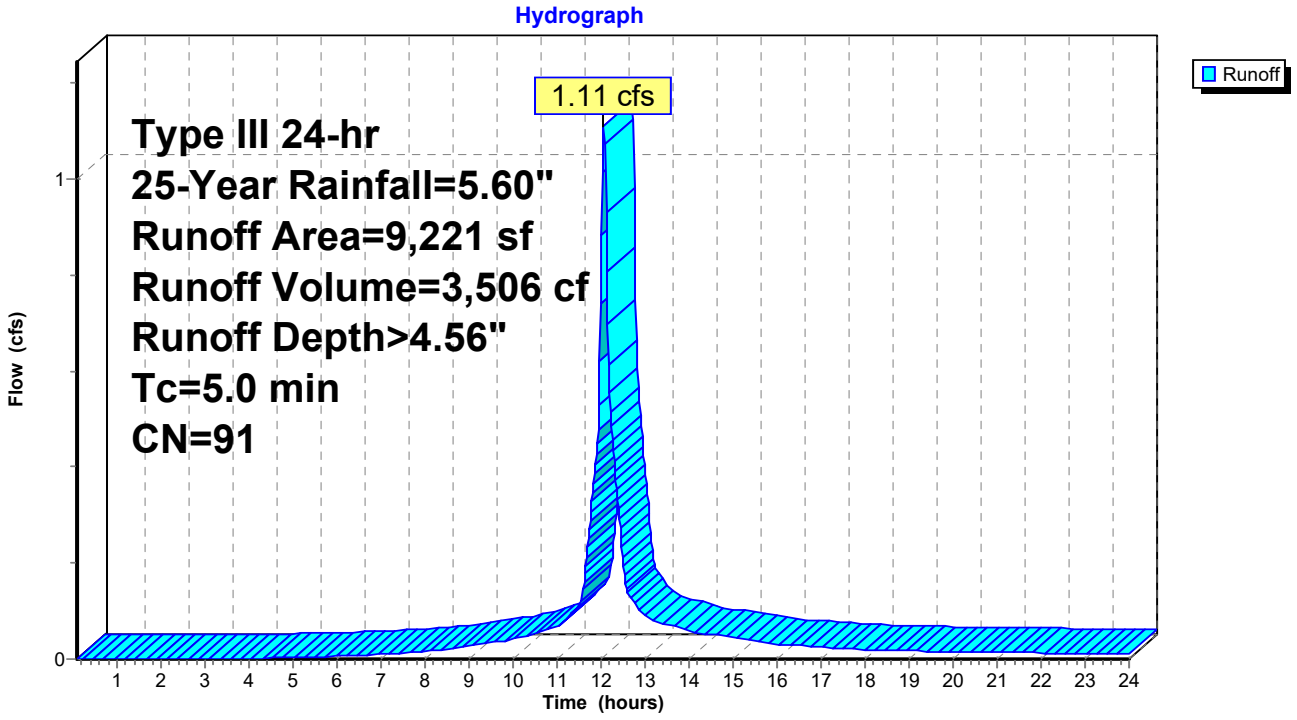
Runoff = 1.11 cfs @ 12.07 hrs, Volume= 3,506 cf, Depth> 4.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

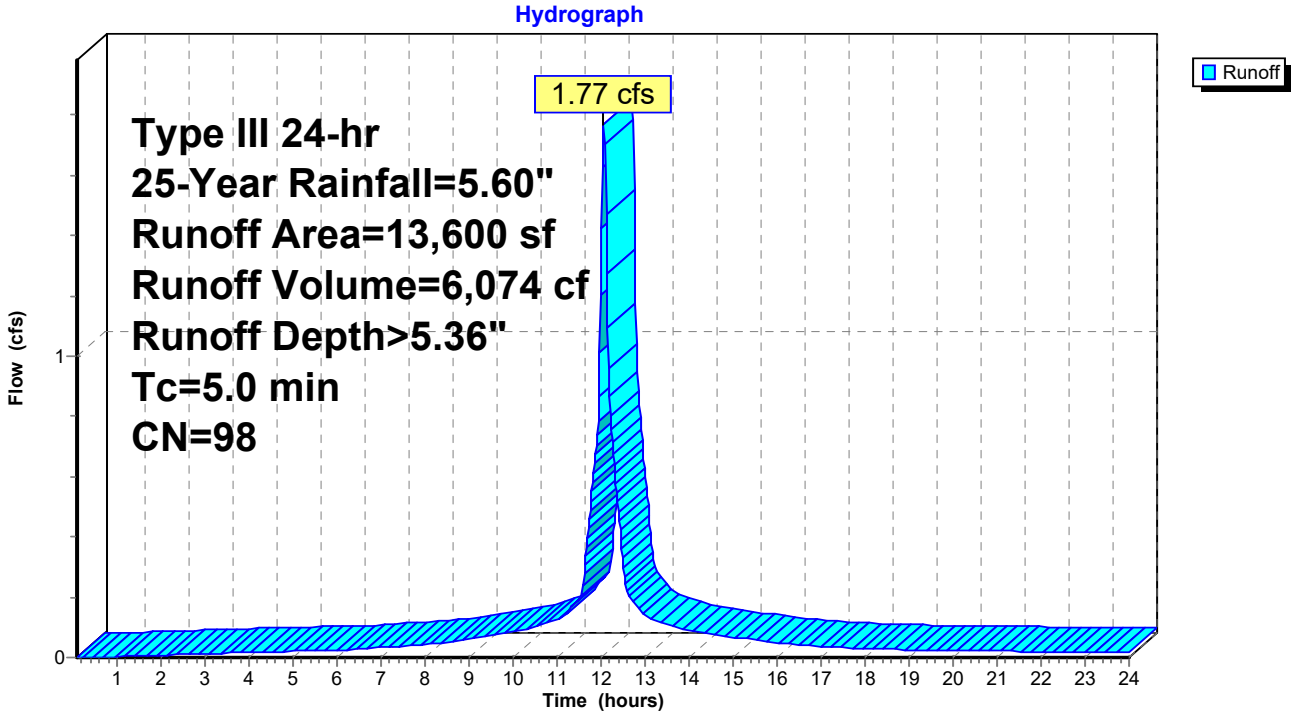
Runoff = 1.77 cfs @ 12.07 hrs, Volume= 6,074 cf, Depth> 5.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
13,600	98	Unconnected roofs, HSG C
13,600		100.00% Impervious Area
13,600		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

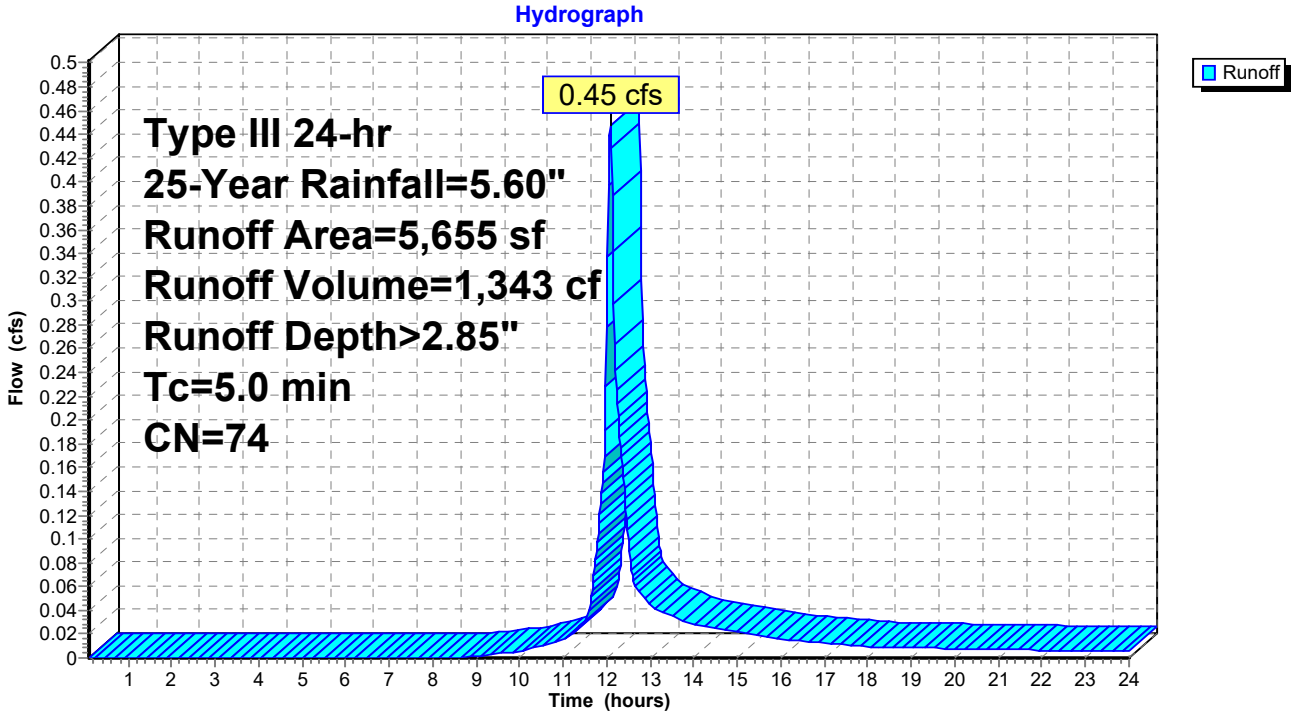
Runoff = 0.45 cfs @ 12.08 hrs, Volume= 1,343 cf, Depth> 2.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
5,655	74	>75% Grass cover, Good, HSG C
5,655		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Subcatchment 6 POST: Post 6

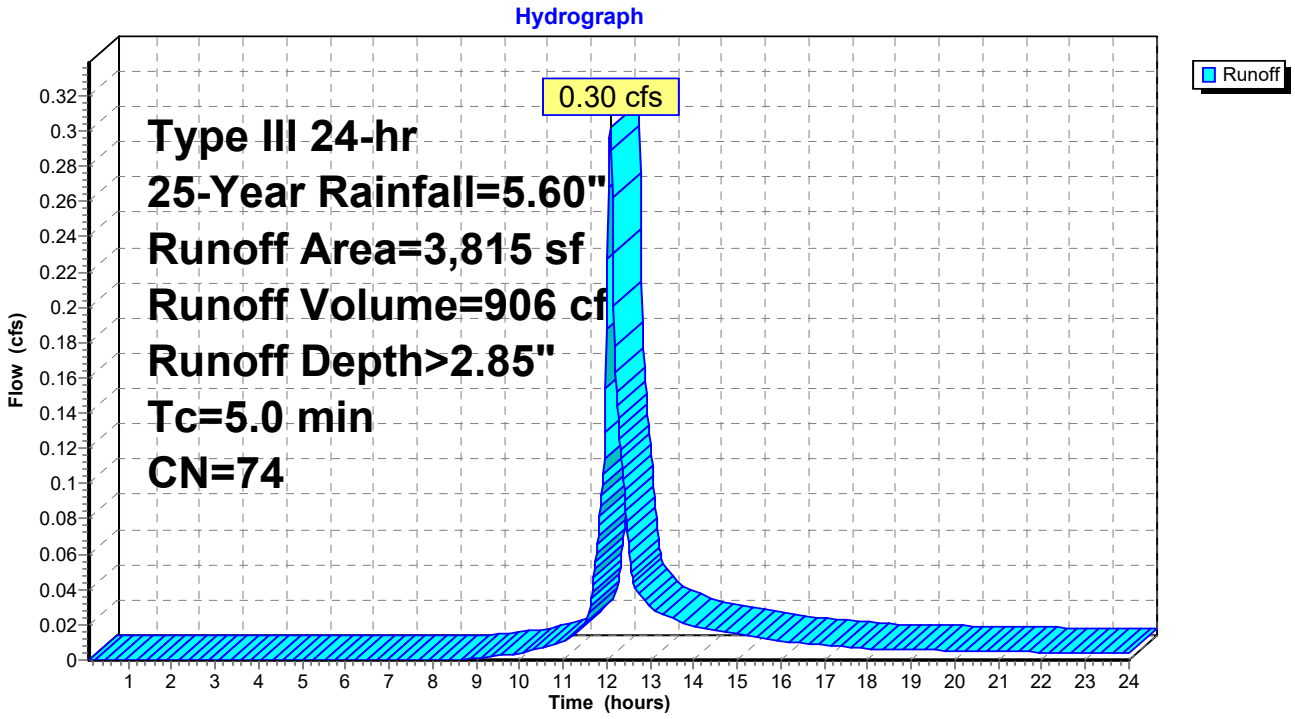
Runoff = 0.30 cfs @ 12.08 hrs, Volume= 906 cf, Depth> 2.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-Year Rainfall=5.60"

Area (sf)	CN	Description
949	79	50-75% Grass cover, Fair, HSG C
2,866	73	Woods, Fair, HSG C
3,815	74	Weighted Average
3,815		100.00% Pervious Area

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

Subcatchment 6 POST: Post 6



Summary for Pond 7R: Rain Garden

Inflow Area = 19,255 sf, 70.63% Impervious, Inflow Depth > 4.62" for 25-Year event
Inflow = 2.21 cfs @ 12.07 hrs, Volume= 7,416 cf
Outflow = 2.07 cfs @ 12.10 hrs, Volume= 5,746 cf, Atten= 7%, Lag= 1.8 min
Primary = 2.07 cfs @ 12.10 hrs, Volume= 5,746 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 197.66' @ 12.10 hrs Surf.Area= 2,235 sf Storage= 2,000 cf

Plug-Flow detention time= 153.8 min calculated for 5,741 cf (77% of inflow)
Center-of-Mass det. time= 71.0 min (831.3 - 760.4)

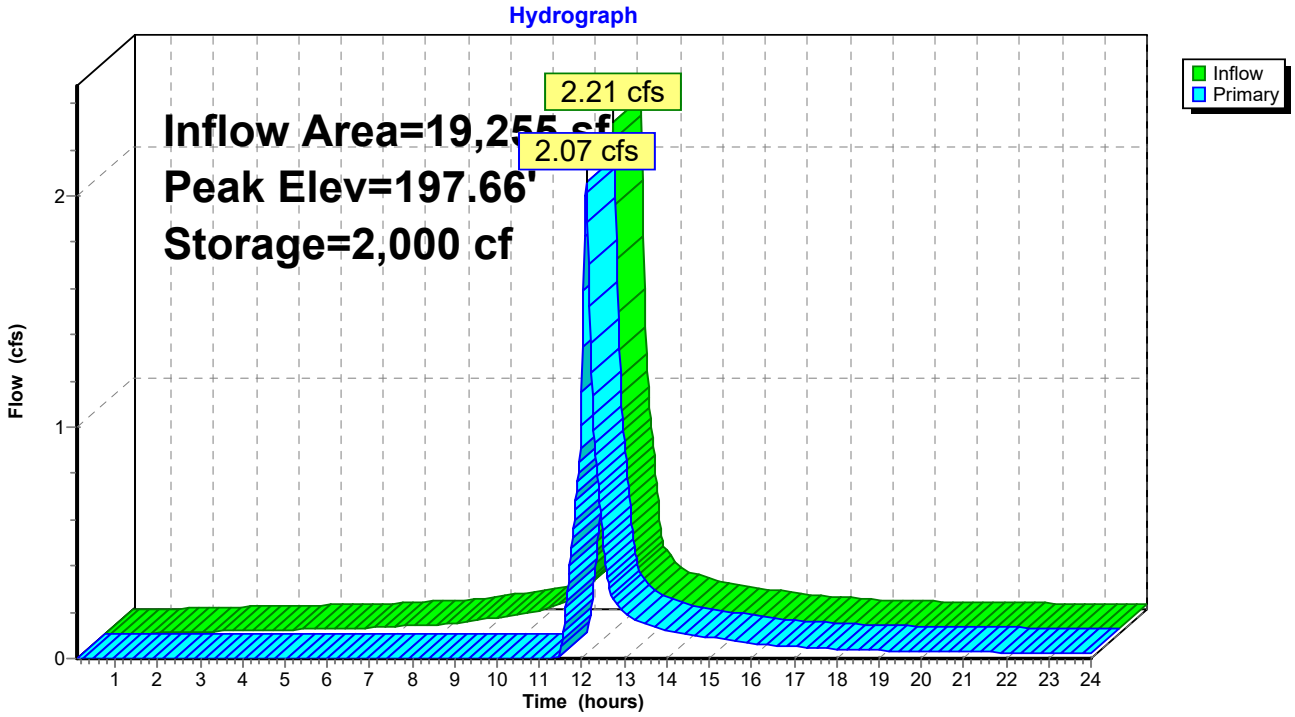
Volume	Invert	Avail.Storage	Storage Description
#1	196.00'	2,838 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
196.00	231	0	0
197.00	1,384	808	808
198.00	2,676	2,030	2,838

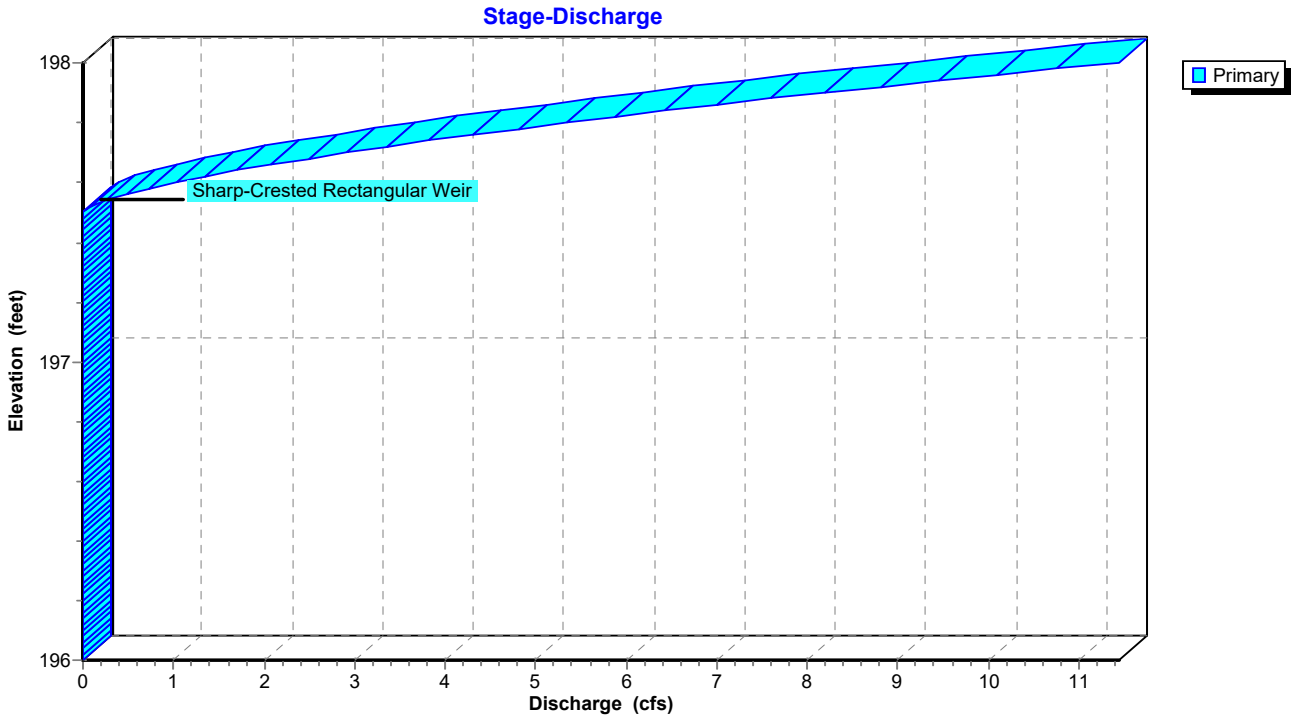
Device	Routing	Invert	Outlet Devices
#1	Primary	197.50'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=2.06 cfs @ 12.10 hrs HW=197.66' (Free Discharge)
↑—**1=Sharp-Crested Rectangular Weir** (Weir Controls 2.06 cfs @ 1.30 fps)

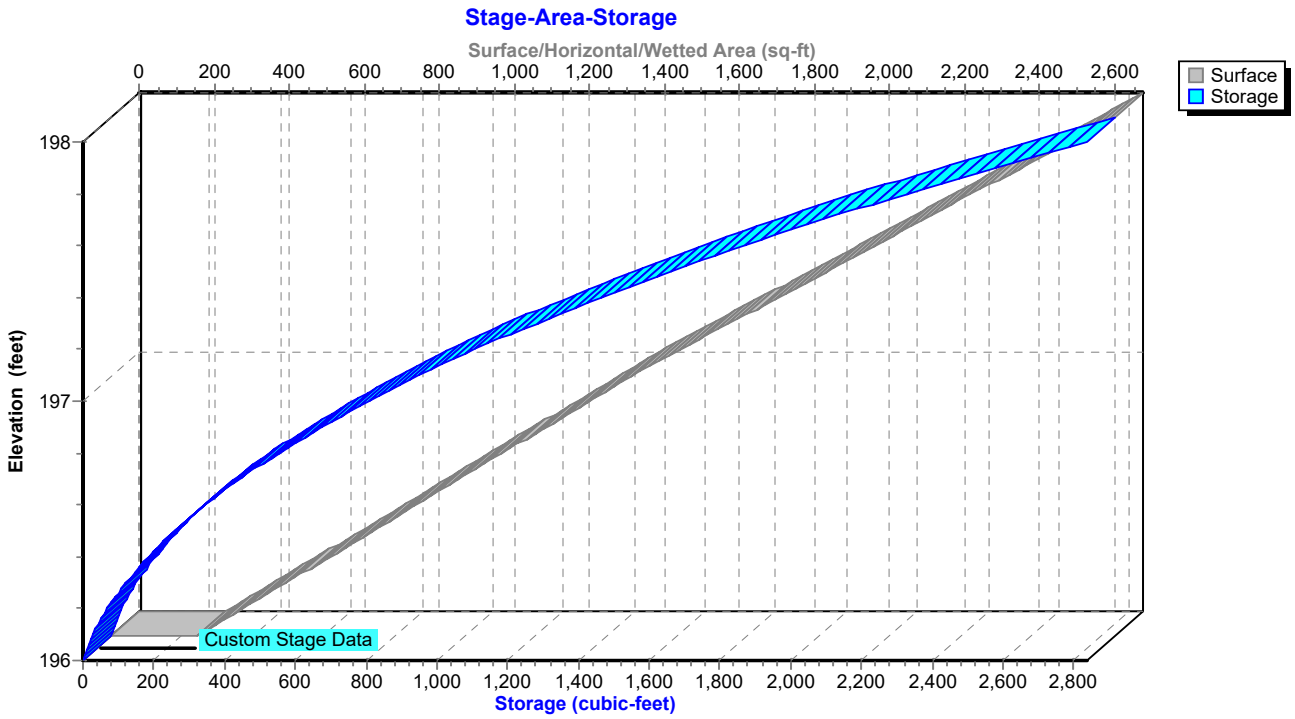
Pond 7R: Rain Garden



Pond 7R: Rain Garden



Pond 7R: Rain Garden

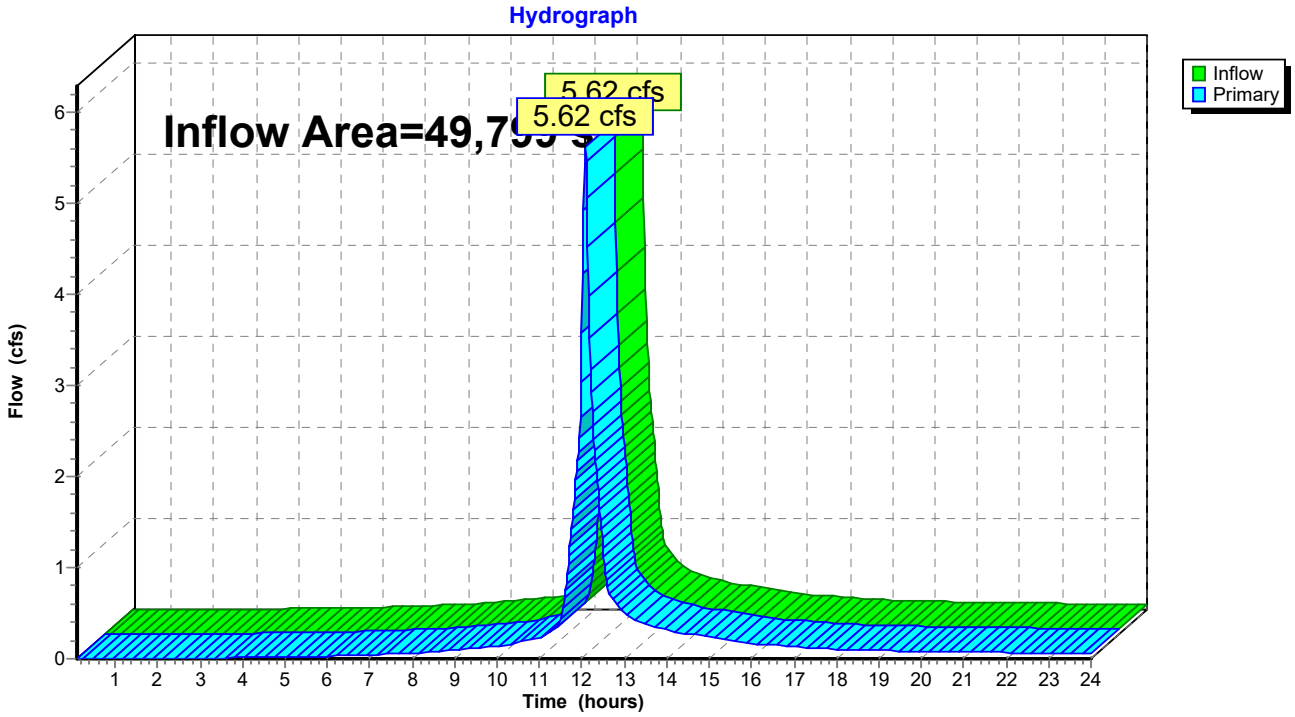


Summary for Link 8L: North West/East Wetland

Inflow Area = 49,799 sf, 43.39% Impervious, Inflow Depth > 4.21" for 25-Year event
Inflow = 5.62 cfs @ 12.08 hrs, Volume= 17,470 cf
Primary = 5.62 cfs @ 12.08 hrs, Volume= 17,470 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 8L: North West/East Wetland

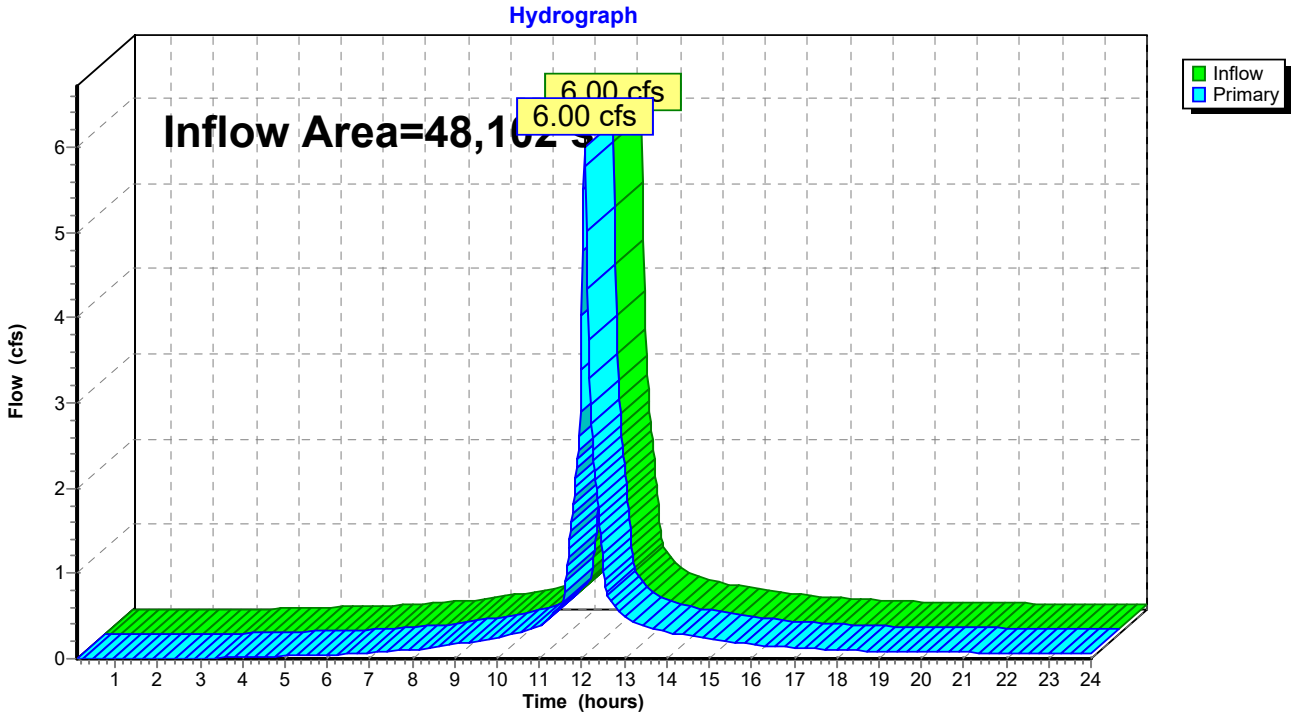


Summary for Link 9L: North West/East Wetland

Inflow Area = 48,102 sf, 45.29% Impervious, Inflow Depth > 4.83" for 25-Year event
Inflow = 6.00 cfs @ 12.07 hrs, Volume= 19,375 cf
Primary = 6.00 cfs @ 12.07 hrs, Volume= 19,375 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 9L: North West/East Wetland



Time span=0.10-24.00 hrs, dt=0.02 hrs, 1196 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1 POST: Post 1	Runoff Area=16,291 sf 59.03% Impervious Runoff Depth>5.82" Tc=5.0 min CN=90 Runoff=2.49 cfs 7,900 cf
Subcatchment 1 PRE: Pre 1	Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>5.93" Tc=5.0 min CN=91 Runoff=2.78 cfs 8,896 cf
Subcatchment 2 POST: Post 2	Runoff Area=17,508 sf 39.02% Impervious Runoff Depth>6.40" Tc=5.0 min CN=95 Runoff=2.81 cfs 9,340 cf
Subcatchment 2 PRE: Pre 2	Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>6.28" Tc=5.0 min CN=94 Runoff=6.18 cfs 20,362 cf
Subcatchment 3 Post: Post 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>5.93" Tc=5.0 min CN=91 Runoff=1.42 cfs 4,560 cf
Subcatchment 3 PRE: Pre 3	Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>5.93" Tc=5.0 min CN=91 Runoff=1.42 cfs 4,560 cf
Subcatchment 4 POST: Post 4	Runoff Area=13,600 sf 100.00% Impervious Runoff Depth>6.76" Tc=5.0 min CN=98 Runoff=2.21 cfs 7,658 cf
Subcatchment 5 POST: Post 5	Runoff Area=5,655 sf 0.00% Impervious Runoff Depth>4.04" Tc=5.0 min CN=74 Runoff=0.64 cfs 1,903 cf
Subcatchment 6 POST: Post 6	Runoff Area=3,815 sf 0.00% Impervious Runoff Depth>4.04" Tc=5.0 min CN=74 Runoff=0.43 cfs 1,284 cf
Pond 7R: Rain Garden	Peak Elev=197.69' Storage=2,067 cf Inflow=2.85 cfs 9,561 cf Outflow=2.68 cfs 7,888 cf
Link 8L: North West/East Wetland	Inflow=7.24 cfs 23,073 cf Primary=7.24 cfs 23,073 cf
Link 9L: North West/East Wetland	Inflow=7.61 cfs 24,922 cf Primary=7.61 cfs 24,922 cf

Total Runoff Area = 132,180 sf Runoff Volume = 66,464 cf Average Runoff Depth = 6.03"
51.23% Pervious = 67,720 sf 48.77% Impervious = 64,460 sf

Summary for Subcatchment 1 POST: Post 1

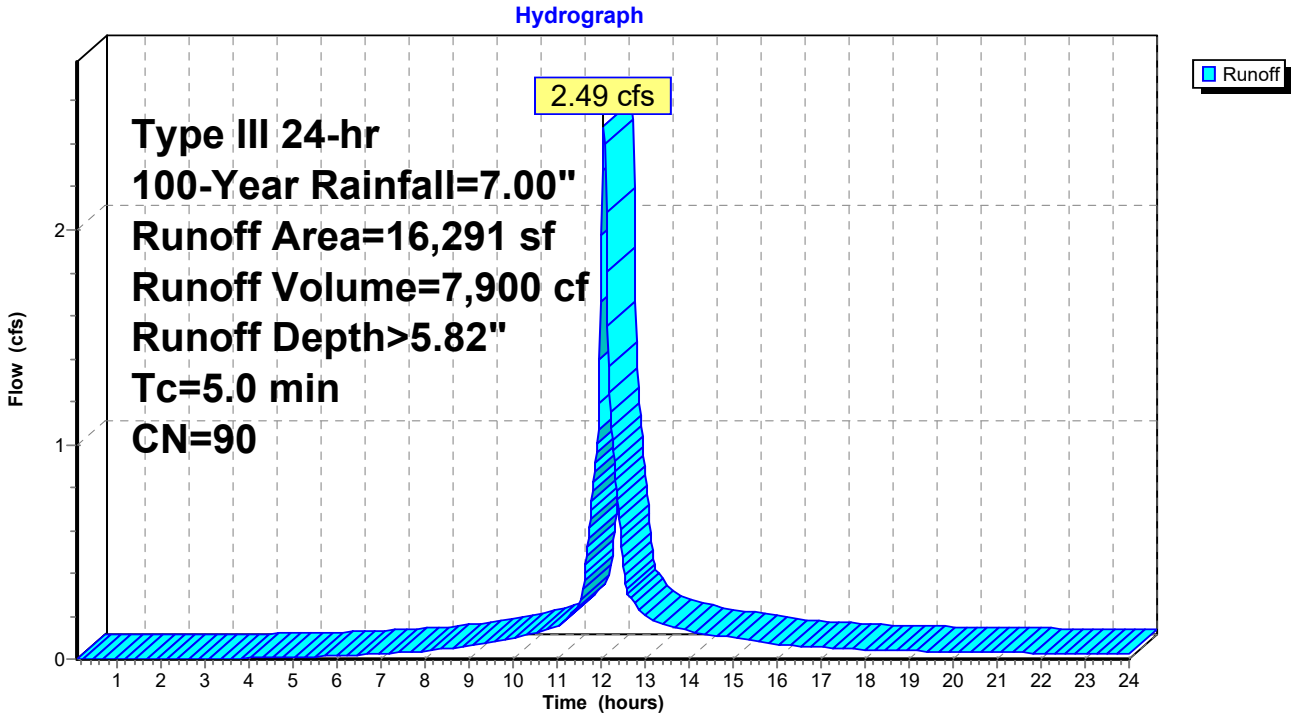
Runoff = 2.49 cfs @ 12.07 hrs, Volume= 7,900 cf, Depth> 5.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,910	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
9,617	98	Paved parking, HSG C
16,291	90	Weighted Average
6,674		40.97% Pervious Area
9,617		59.03% Impervious Area

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

Subcatchment 1 POST: Post 1



Summary for Subcatchment 1 PRE: Pre 1

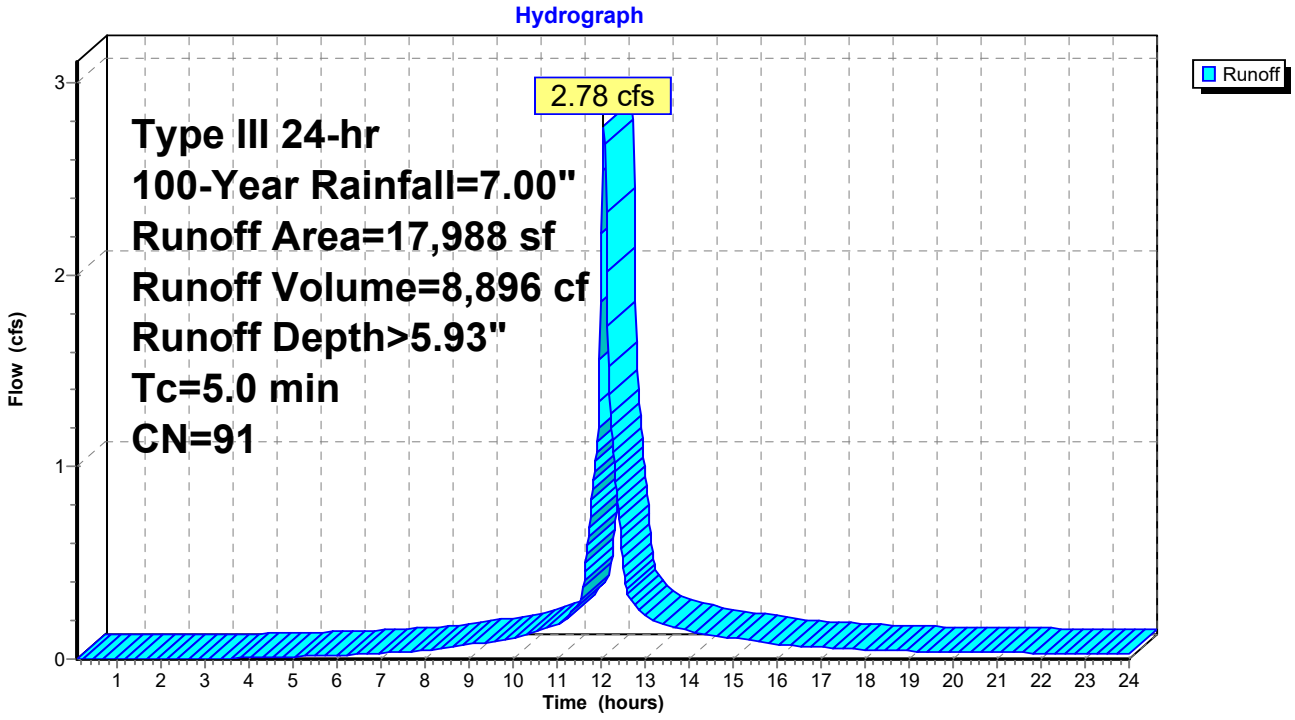
Runoff = 2.78 cfs @ 12.07 hrs, Volume= 8,896 cf, Depth> 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,774	79	50-75% Grass cover, Fair, HSG C
764	73	Woods, Fair, HSG C
11,450	98	Paved parking, HSG C
17,988	91	Weighted Average
6,538		36.35% Pervious Area
11,450		63.65% Impervious Area

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

Subcatchment 1 PRE: Pre 1



Summary for Subcatchment 2 POST: Post 2

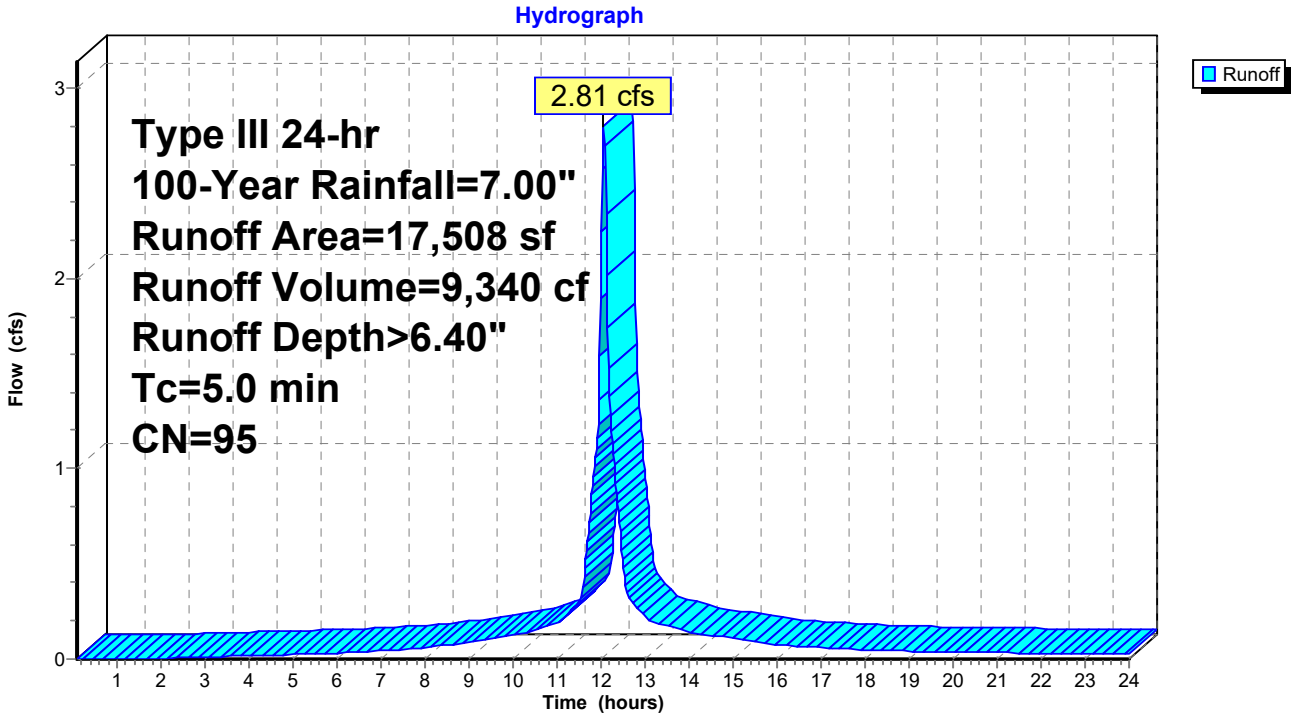
Runoff = 2.81 cfs @ 12.07 hrs, Volume= 9,340 cf, Depth> 6.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
1,348	73	Woods, Fair, HSG C
6,831	98	Paved parking, HSG C
9,329	96	Gravel surface, HSG C
17,508	95	Weighted Average
10,677		60.98% Pervious Area
6,831		39.02% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

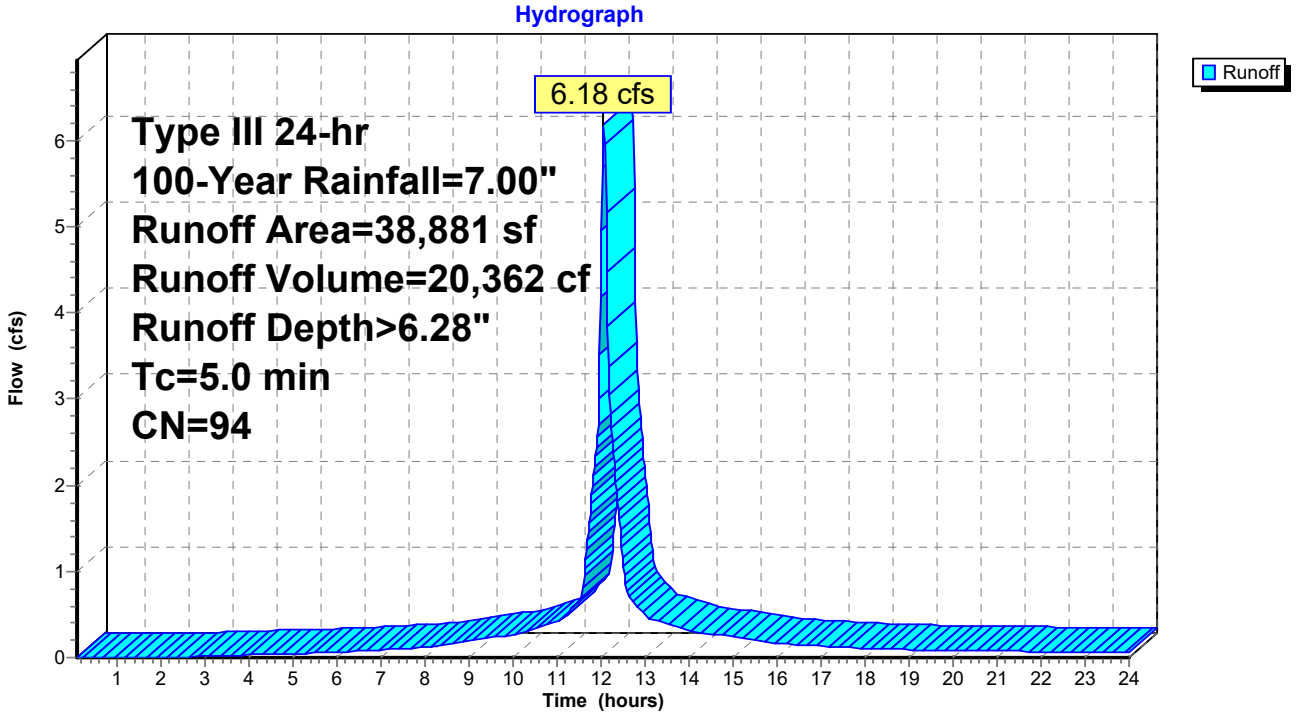
Runoff = 6.18 cfs @ 12.07 hrs, Volume= 20,362 cf, Depth> 6.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
4,958	73	Woods, Fair, HSG C
6,631	98	Roofs, HSG C
13,977	98	Paved parking, HSG C
13,315	96	Gravel surface, HSG C
38,881	94	Weighted Average
18,273		47.00% Pervious Area
20,608		53.00% Impervious Area

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

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

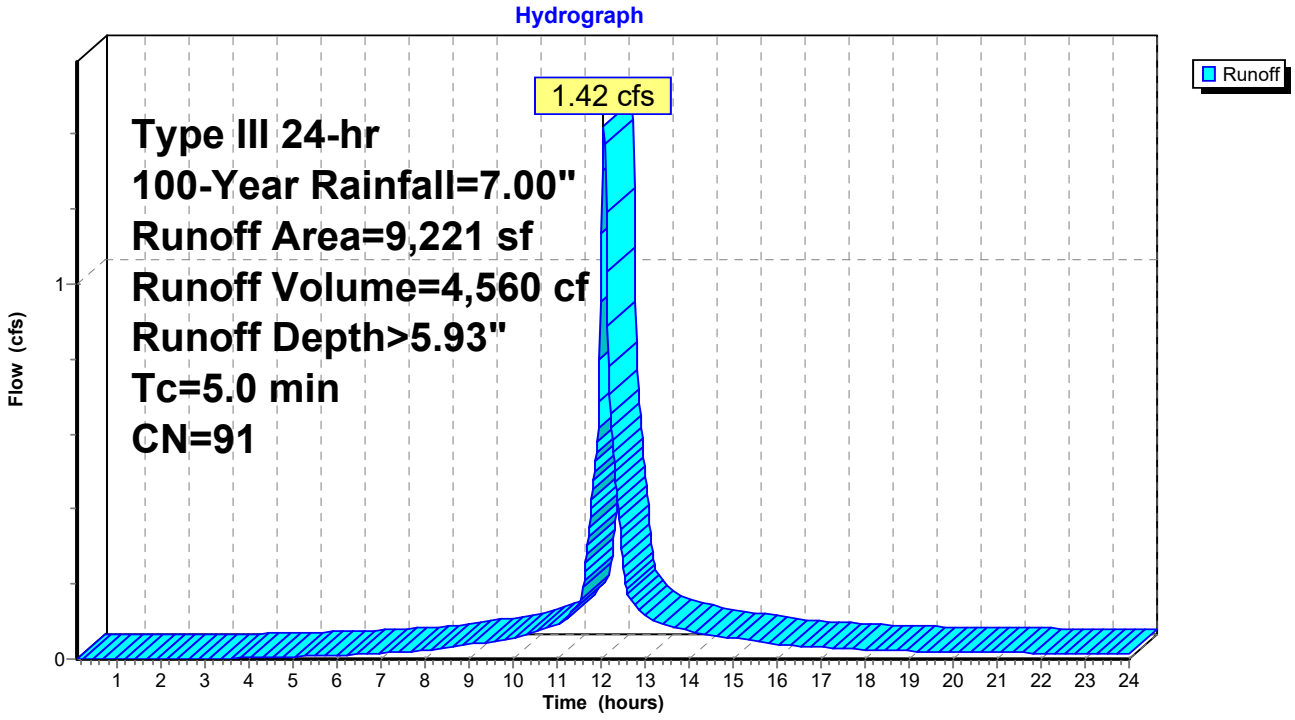
Runoff = 1.42 cfs @ 12.07 hrs, Volume= 4,560 cf, Depth> 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

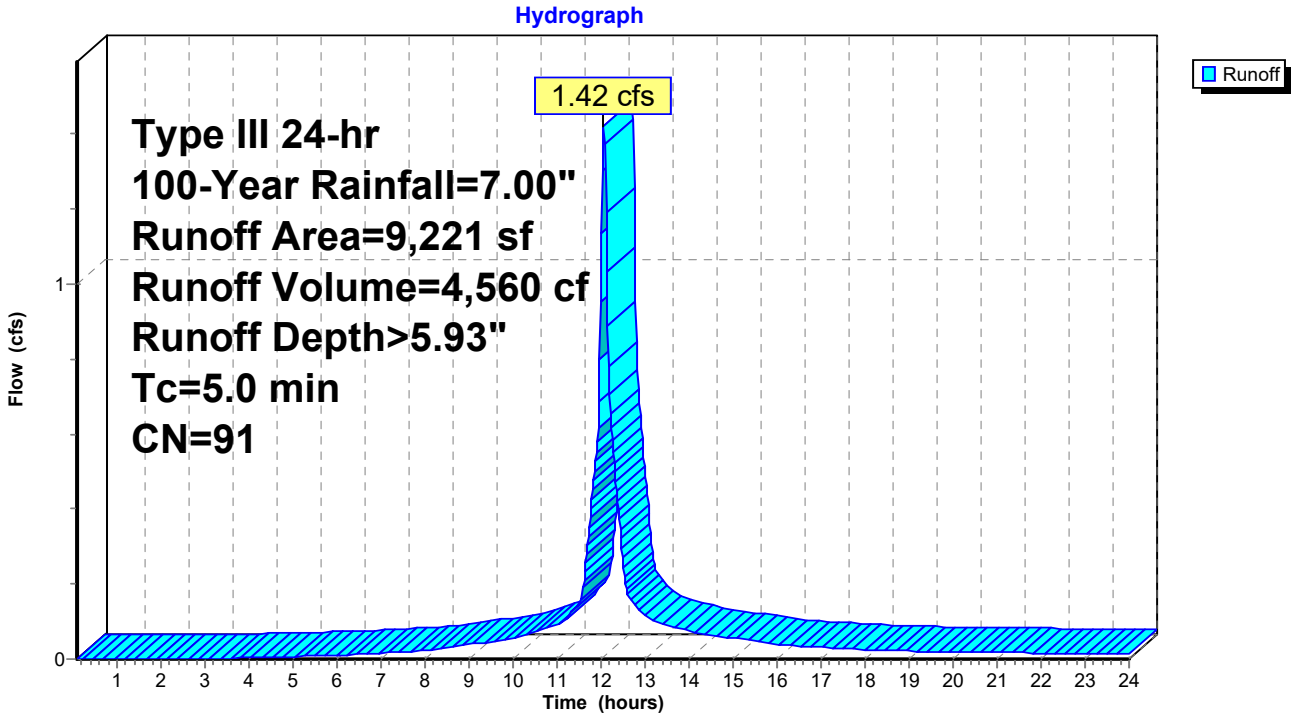
Runoff = 1.42 cfs @ 12.07 hrs, Volume= 4,560 cf, Depth> 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG C
1,177	98	Paved parking, HSG C
2,116	73	Woods, Fair, HSG C
9,221	91	Weighted Average
8,044		87.24% Pervious Area
1,177		12.76% Impervious Area

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

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

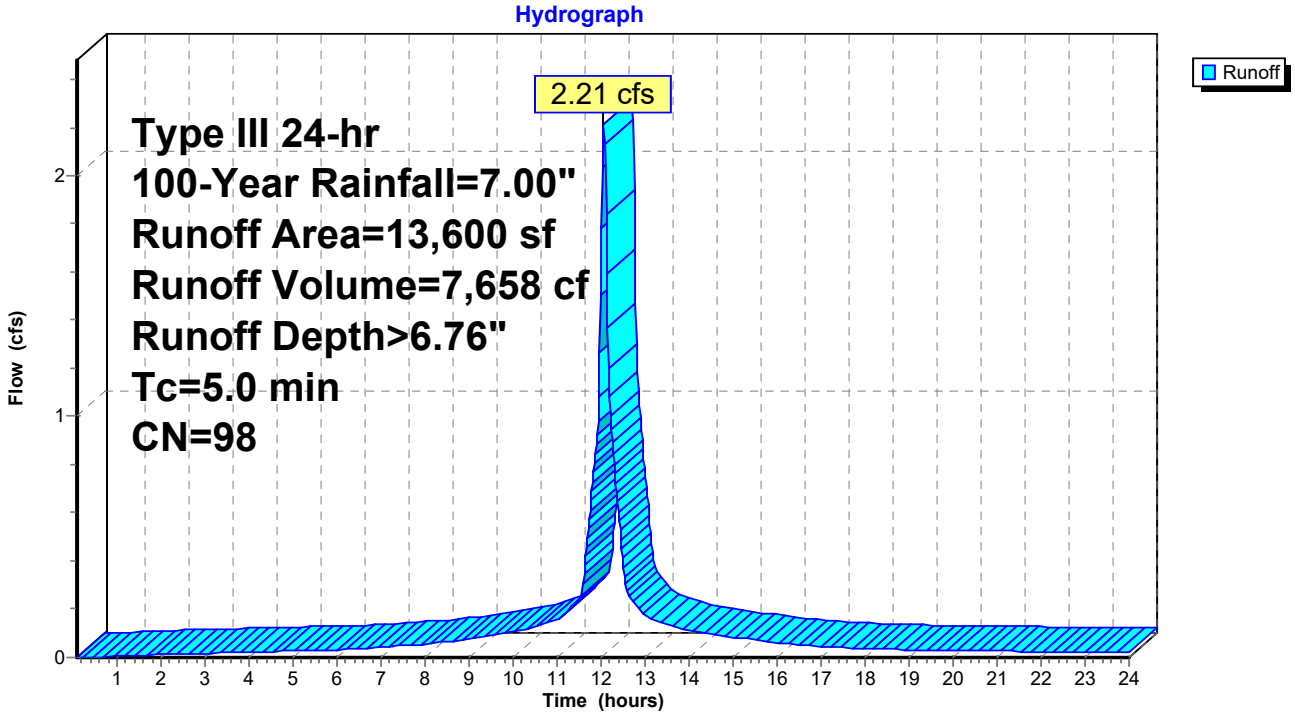
Runoff = 2.21 cfs @ 12.07 hrs, Volume= 7,658 cf, Depth> 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
13,600	98	Unconnected roofs, HSG C
13,600		100.00% Impervious Area
13,600		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

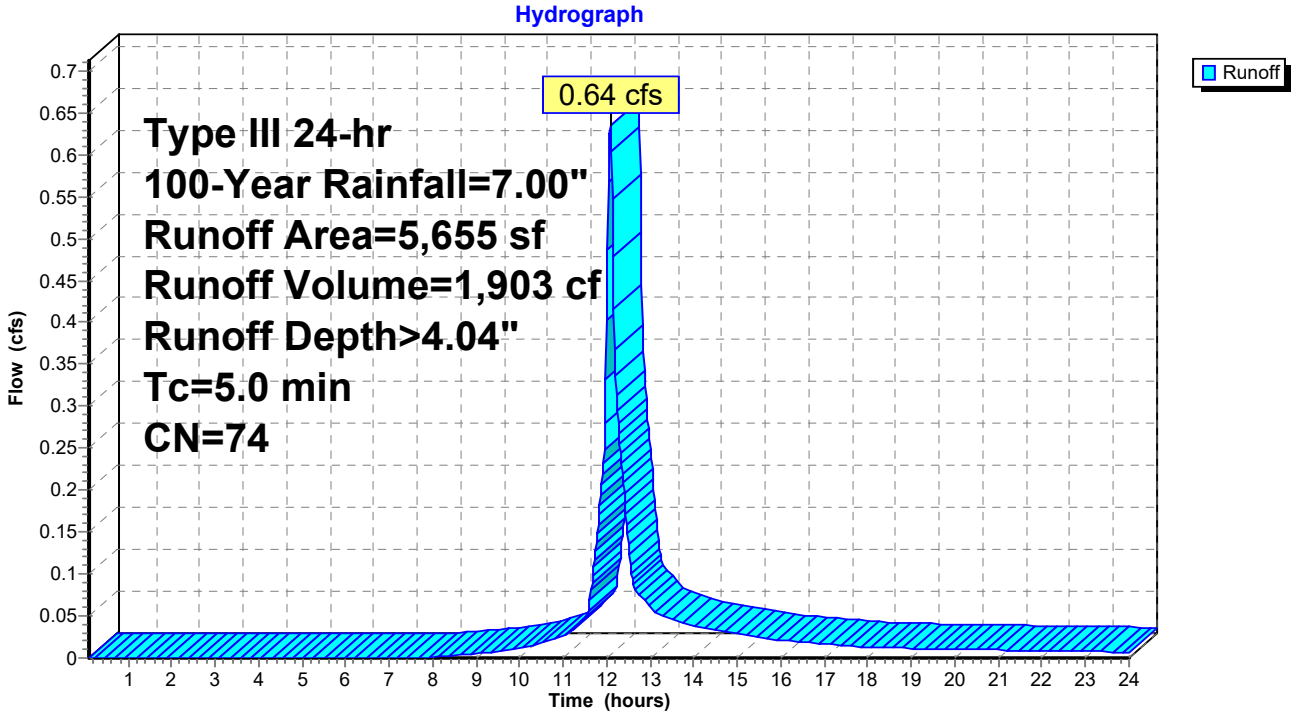
Runoff = 0.64 cfs @ 12.08 hrs, Volume= 1,903 cf, Depth> 4.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
5,655	74	>75% Grass cover, Good, HSG C
5,655		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Subcatchment 6 POST: Post 6

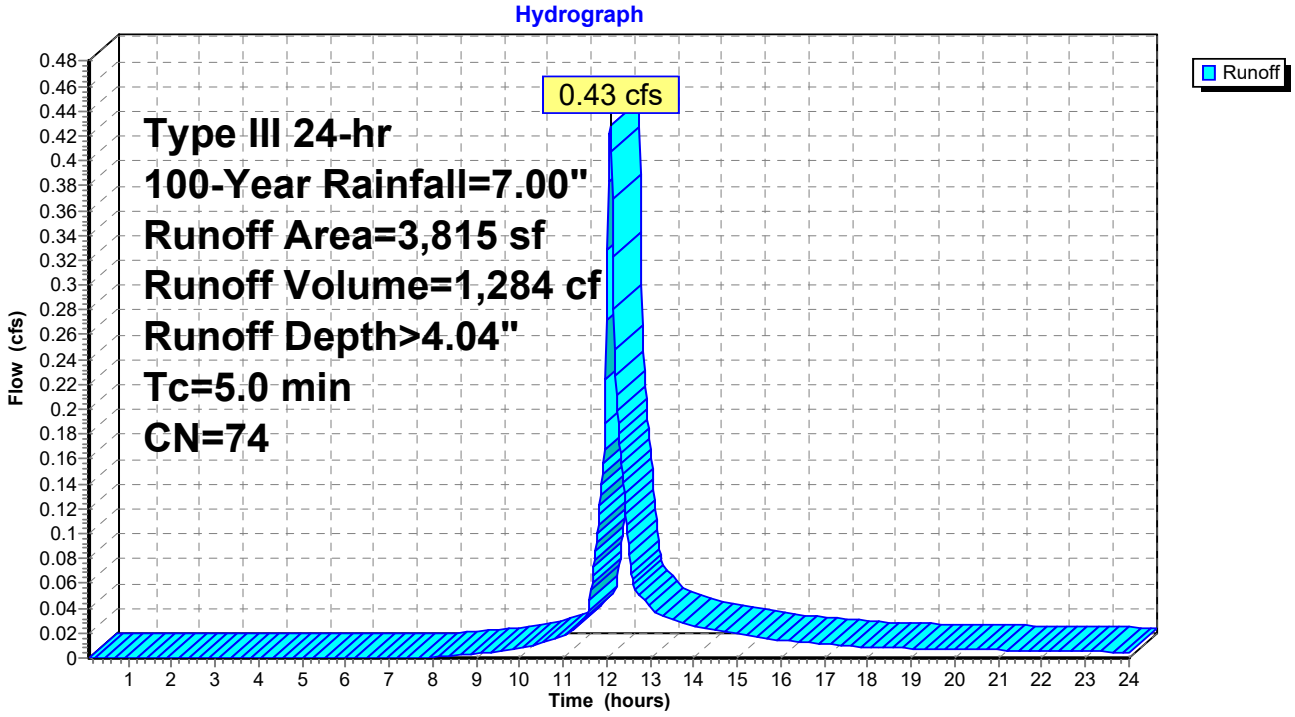
Runoff = 0.43 cfs @ 12.08 hrs, Volume= 1,284 cf, Depth> 4.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Type III 24-hr 100-Year Rainfall=7.00"

Area (sf)	CN	Description
949	79	50-75% Grass cover, Fair, HSG C
2,866	73	Woods, Fair, HSG C
3,815	74	Weighted Average
3,815		100.00% Pervious Area

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

Subcatchment 6 POST: Post 6



Summary for Pond 7R: Rain Garden

Inflow Area = 19,255 sf, 70.63% Impervious, Inflow Depth > 5.96" for 100-Year event
Inflow = 2.85 cfs @ 12.07 hrs, Volume= 9,561 cf
Outflow = 2.68 cfs @ 12.10 hrs, Volume= 7,888 cf, Atten= 6%, Lag= 1.7 min
Primary = 2.68 cfs @ 12.10 hrs, Volume= 7,888 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 197.69' @ 12.10 hrs Surf.Area= 2,274 sf Storage= 2,067 cf

Plug-Flow detention time= 134.4 min calculated for 7,888 cf (83% of inflow)
Center-of-Mass det. time= 62.5 min (819.8 - 757.3)

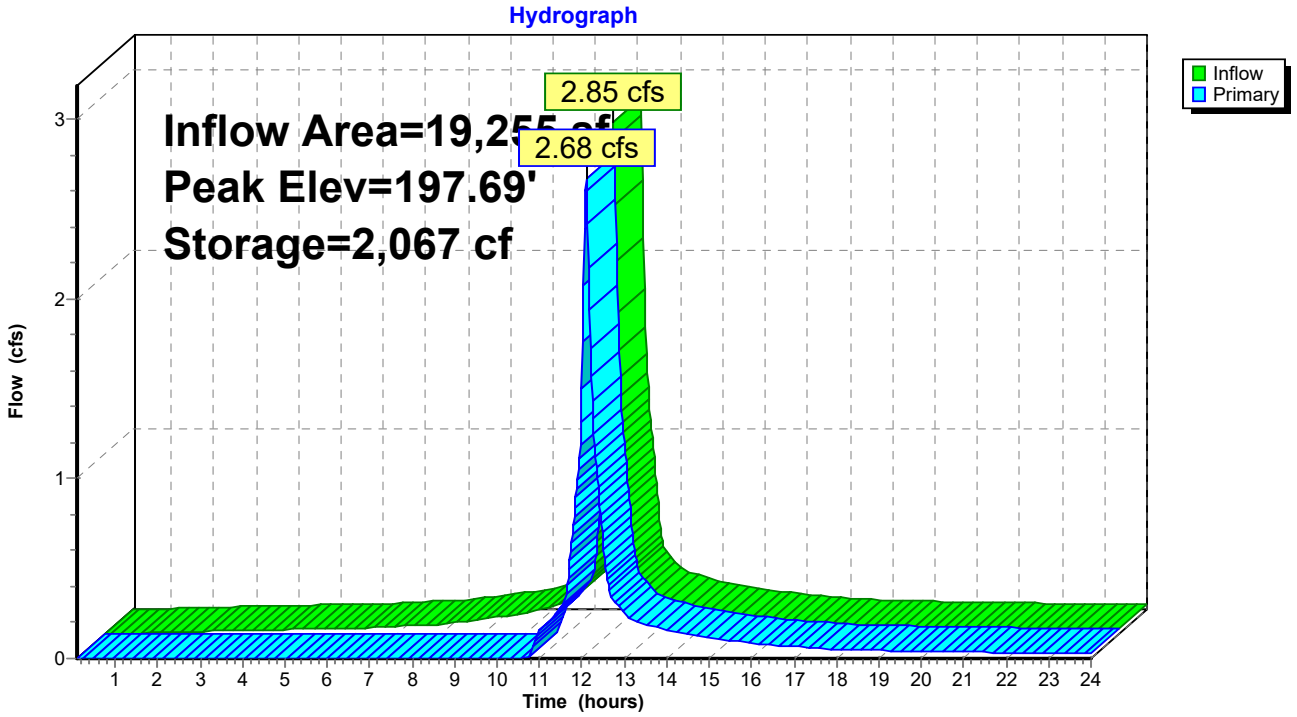
Volume	Invert	Avail.Storage	Storage Description
#1	196.00'	2,838 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
196.00	231	0	0
197.00	1,384	808	808
198.00	2,676	2,030	2,838

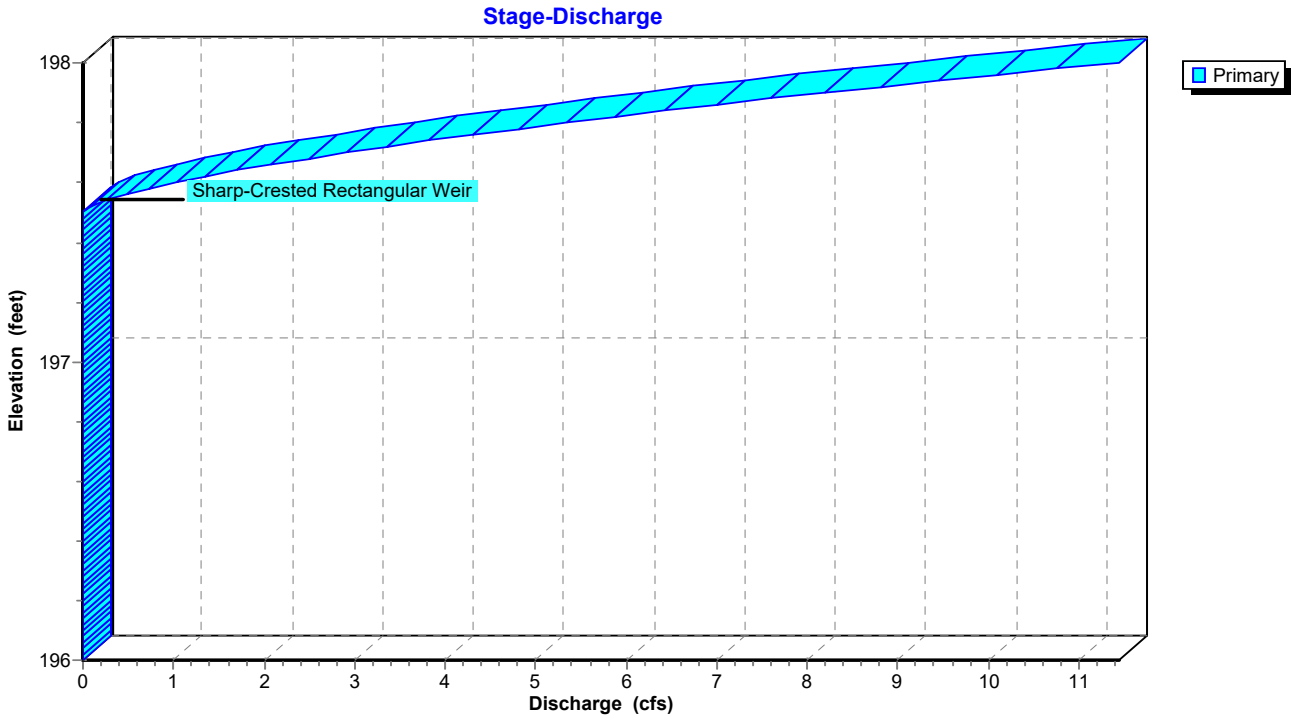
Device	Routing	Invert	Outlet Devices
#1	Primary	197.50'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Primary OutFlow Max=2.67 cfs @ 12.10 hrs HW=197.69' (Free Discharge)
↑—**1=Sharp-Crested Rectangular Weir** (Weir Controls 2.67 cfs @ 1.42 fps)

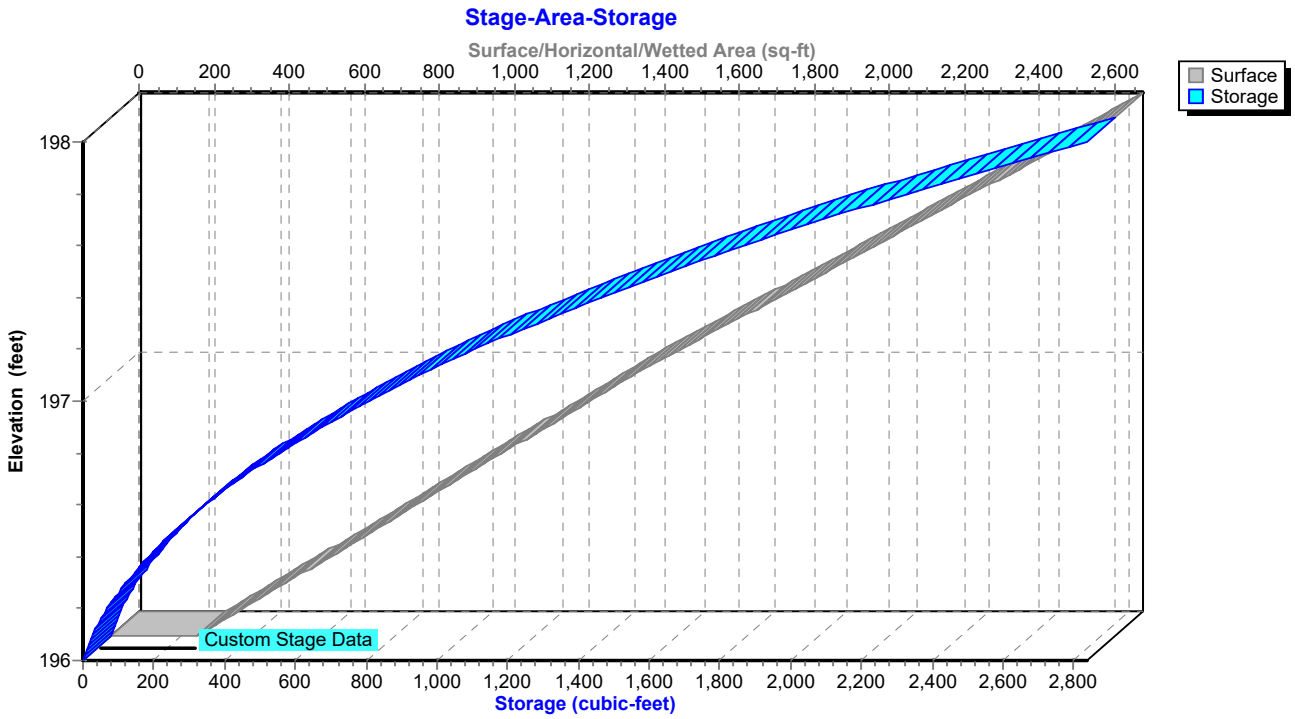
Pond 7R: Rain Garden



Pond 7R: Rain Garden



Pond 7R: Rain Garden

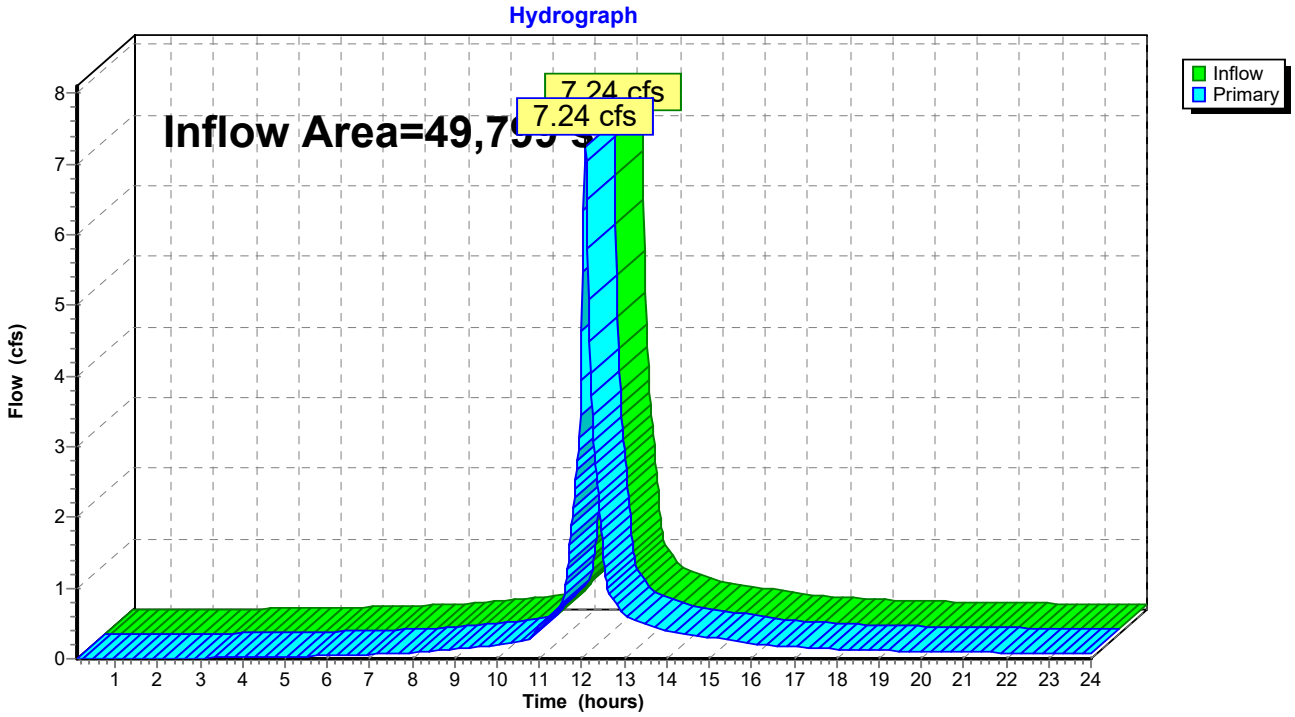


Summary for Link 8L: North West/East Wetland

Inflow Area = 49,799 sf, 43.39% Impervious, Inflow Depth > 5.56" for 100-Year event
Inflow = 7.24 cfs @ 12.08 hrs, Volume= 23,073 cf
Primary = 7.24 cfs @ 12.08 hrs, Volume= 23,073 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 8L: North West/East Wetland

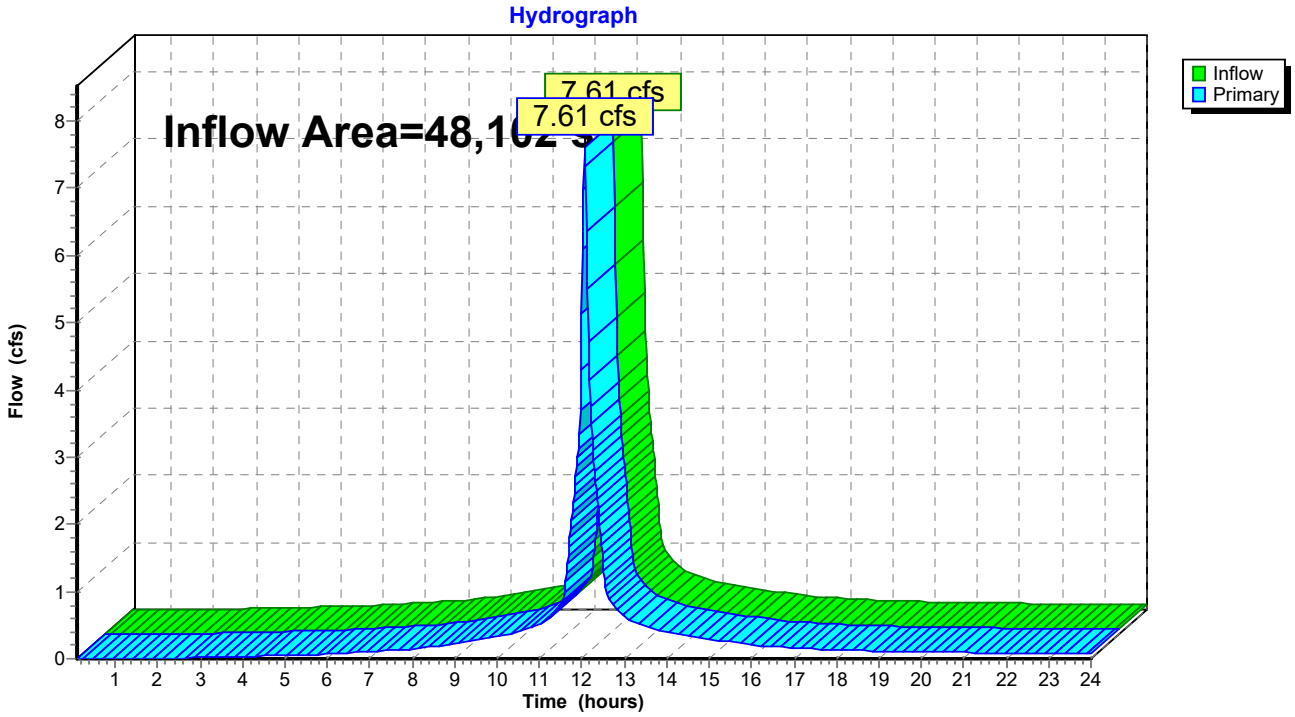


Summary for Link 9L: North West/East Wetland

Inflow Area = 48,102 sf, 45.29% Impervious, Inflow Depth > 6.22" for 100-Year event
Inflow = 7.61 cfs @ 12.07 hrs, Volume= 24,922 cf
Primary = 7.61 cfs @ 12.07 hrs, Volume= 24,922 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs

Link 9L: North West/East Wetland



Section III

OPERATION AND MAINTENANCE PLAN

PROPOSED DRAINAGE SYSTEM – DURING CONSTRUCTION
540 Bodwell Street Ext.
Avon, MA 02359

Owner: CJ Shaughnessy Realty Trust
520 Bodwell Street Ext.
Avon, MA 02322
Contact: Chris Shaughnessy (781-315-5321)

Party Responsible for Operation and Maintenance:

CJ Shaughnessy Realty Trust
520 Bodwell Street Ext.
Avon, MA 02322
Contact: Chris Shaughnessy (781-315-5321)

Source of Funding:

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

During Construction:

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

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

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

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

Heavy equipment shall not be used on basin bottoms.

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

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

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

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

Inspections

The Owner shall be responsible to secure the services of a Professional Engineer to perform inspections as required. Inspections during periods of active construction shall be weekly and within 24 hours of a storm event of greater than ½ “. The Professional Engineer shall perform inspections to insure that the approved plan is being followed with particular attention to the Planning Board Approval and the Construction Sequencing. The Engineer shall be responsible for inspecting the roadway construction and the construction of the stormwater management system. The Engineer shall prepare and submit to the Planning Board, the Inspection Schedule and Evaluation Checklist (see attached) and, if necessary, request the required maintenance and/or repair of the necessary items. This form shall be stamped by the Engineer and the Owner shall be notified that specific changes and/or repairs are necessary.

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

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

PROJECT LOCATION: 540 Bodwell Street Ext – Avon, MA
Latest Revision: 6/29/20

Stormwater Control Manager: _____ **Stamp**

Best Management Practice	Inspection Frequency (1)	Date Inspected	Inspector	Minimum Maintenance and Key Items to Check	Cleaning / Repair Needed yes/no List items	Date of Cleaning/Repair	Performed By	Water Level in Detention System
Silt fence & swales and silt traps	After every major storm event							
Temporary Construction Entrance	Daily or as needed.							
Outlet control structure + Flow dissipator	After every major storm event							

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

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

PROPOSED DRAINAGE SYSTEM – DURING CONSTRUCTION
540 Bodwell Street Ext.
Avon, MA 02359

Owner:

CJ Shaughnessy Realty Trust
520 Bodwell Street Ext.
Avon, MA 02322
Contact: Chris Shaughnessy (781-315-5321)

Party Responsible for Operation and Maintenance:

CJ Shaughnessy Realty Trust
520 Bodwell Street Ext.
Avon, MA 02322
Contact: Chris Shaughnessy (781-315-5321)

Source of Funding:
Operation and Maintenance of this stormwater management system will be the responsibility of the owners and funding for operation and maintenance of the stormwater management system will be the responsibility of the Department of Public Works.

Post Construction Inspection and Maintenance:

Bio-Retention Basin

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

The infiltration basins should be inspected quarterly and at least once per year to ensure that the system is operating as intended. If accumulated sediment is observed within the basin it should be removed from the basin as necessary. Any sediment removed from the infiltration systems should be disposed of in accordance with Town, State and Federal Regulations. The system including the stormwater discharge locations should also be inspected for growth of any invasive species and removed if found.

The embankments of the basin shall be mowed periodically, to prevent the establishment of woody vegetation on the berms. Embankments and spillways shall be inspected annually for general structural integrity, with immediate corrective action as warranted by inspection.

Lawn Fertilization

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

Definition of Major Storm Event

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

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

STORMWATER MANAGEMENT
BEST MANAGEMENT PRACTICES

INSPECTION SCHEDULE AND EVALUATION CHECKLIST – POST CONSTRUCTION PHASE

PROJECT LOCATION: 540 Bodwell Street Ext – Avon, MA
Latest Revision: 6/29/20

Best Management Practice	Inspection Frequency (1)	Date Inspected	Inspector	Minimum Maintenance and Key Items to Check	Cleaning/ Repair Needed yes/no List items	Date of Cleaning/Repair	Performed By	Water Level in Detention System
Roof Drains	Twice per							
Infiltration Basin	Twice per year							

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

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

Stormwater Control Manager: _____ **Stamp**

United States Department of Agriculture

NRCS

Natural Resources Conservation Service

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

Custom Soil Resource Report for Norfolk and Suffolk Counties, Massachusetts

May 22, 2020

Preface

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

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

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

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

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

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

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

How Soil Surveys Are Made

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

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

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

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

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

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

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

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

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

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

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

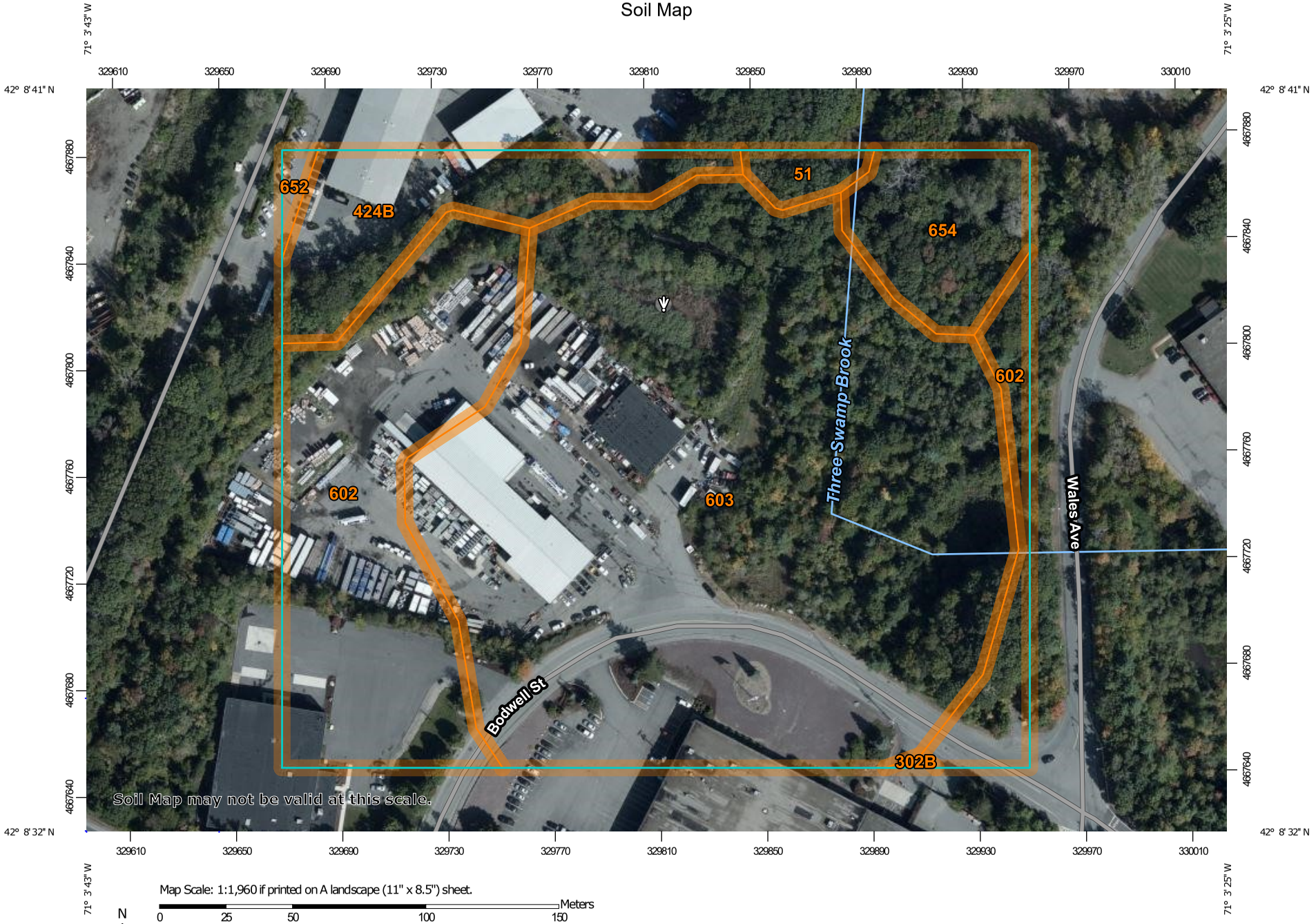
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

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

Custom Soil Resource Report
Soil Map



Map Scale: 1:1,960 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 25 50 100 150

Feet: 0 50 100 200 300

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: Norfolk and Suffolk Counties, Massachusetts
Survey Area Data: Version 15, Sep 12, 2019

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

Date(s) aerial images were photographed: Aug 31, 2019—Sep 24, 2019

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
51	Swansea muck, 0 to 1 percent slopes	0.2	1.2%
302B	Montauk fine sandy loam, 0 to 8 percent slopes, extremely stony	0.0	0.1%
424B	Canton fine sandy loam, 3 to 8 percent slopes, extremely bouldery	1.3	8.2%
602	Urban land, 0 to 15 percent slopes	3.8	23.7%
603	Urban land, wet substratum, 0 to 3 percent slopes	9.8	60.5%
652	Udorthents, refuse substratum	0.1	0.4%
654	Udorthents, loamy	0.9	5.9%
Totals for Area of Interest		**16.2**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit

descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

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

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

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

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

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

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

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

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

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

Norfolk and Suffolk Counties, Massachusetts

51—Swansea muck, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2trl2
Elevation: 0 to 1,140 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Swansea

Setting

Landform: Bogs, swamps
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Highly decomposed organic material over loose sandy and gravelly glaciofluvial deposits

Typical profile

Oa1 - 0 to 24 inches: muck
Oa2 - 24 to 34 inches: muck
Cg - 34 to 79 inches: coarse sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water storage in profile: Very high (about 16.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: B/D
Hydric soil rating: Yes

Minor Components

Freetown

Percent of map unit: 10 percent
Landform: Bogs, swamps
Landform position (three-dimensional): Dip

Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Whitman

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

Scarboro

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

302B—Montauk fine sandy loam, 0 to 8 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2w80t
Elevation: 30 to 1,120 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Montauk, Extremely Stony

Setting

Landform: Hills, drumlins, ground moraines, recessionial moraines
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Linear, convex
Across-slope shape: Convex
Parent material: Coarse-loamy over sandy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 6 inches: fine sandy loam

Bw1 - 6 to 28 inches: fine sandy loam
Bw2 - 28 to 36 inches: sandy loam
2Cd - 36 to 74 inches: gravelly loamy sand

Properties and qualities

Slope: 0 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 20 to 43 inches to densic material
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 1.42 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Salinity, maximum in profile: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water storage in profile: Low (about 5.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Scituate, extremely stony

Percent of map unit: 8 percent
Landform: Hills, drumlins, ground moraines
Landform position (two-dimensional): Footslope, backslope, summit
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Hydric soil rating: No

Canton, extremely stony

Percent of map unit: 5 percent
Landform: Hills
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Side slope, crest
Down-slope shape: Convex, linear
Across-slope shape: Convex
Hydric soil rating: No

Ridgebury, extremely stony

Percent of map unit: 2 percent
Landform: Depressions, drainageways, hills, ground moraines
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

424B—Canton fine sandy loam, 3 to 8 percent slopes, extremely bouldery

Map Unit Setting

National map unit symbol: vkq5
Elevation: 0 to 1,000 feet
Mean annual precipitation: 45 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Canton and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Canton

Setting

Landform: Ice-contact slopes
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Friable coarse-loamy eolian deposits over loose sandy and gravelly ablation till

Typical profile

H1 - 0 to 3 inches: fine sandy loam
H2 - 3 to 18 inches: fine sandy loam
H3 - 18 to 60 inches: gravelly loamy sand

Properties and qualities

Slope: 3 to 8 percent
Percent of area covered with surface fragments: 9.0 percent
Depth to restrictive feature: 18 to 36 inches to strongly contrasting textural stratification
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): High (2.00 to 6.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Very low (about 2.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A

Hydric soil rating: No

Minor Components

Montauk
Percent of map unit: 4 percent
Hydric soil rating: No

Scituate
Percent of map unit: 2 percent
Hydric soil rating: No

Charlton
Percent of map unit: 2 percent
Hydric soil rating: No

Chatfield
Percent of map unit: 2 percent
Hydric soil rating: No

602—Urban land, 0 to 15 percent slopes

Map Unit Setting
National map unit symbol: vkyj
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 45 to 50 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition
Urban land: 99 percent
Minor components: 1 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting
Parent material: Excavated and filled land

Minor Components

Rock outcrops
Percent of map unit: 1 percent
Hydric soil rating: Unranked

603—Urban land, wet substratum, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: vkyl
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 45 to 50 degrees F
Frost-free period: 120 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Parent material: Excavated and filled land over herbaceous organic material and/or alluvium and/or marine deposits

Minor Components

Udorthents

Percent of map unit: 13 percent
Hydric soil rating: Unranked

Beaches

Percent of map unit: 2 percent
Hydric soil rating: Unranked

652—Udorthents, refuse substratum

Map Unit Setting

National map unit symbol: vkyg
Elevation: 0 to 3,000 feet
Mean annual precipitation: 45 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 95 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Setting

Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Riser, tread
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Excavated and filled loamy land over made land, refuse

Typical profile

H1 - 0 to 6 inches: variable
H2 - 6 to 60 inches: variable

Properties and qualities

Slope: 0 to 25 percent
Depth to restrictive feature: More than 80 inches
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.06 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Hydric soil rating: Unranked

Minor Components

Udorthents

Percent of map unit: 5 percent
Hydric soil rating: Unranked

654—Udorthents, loamy

Map Unit Setting

National map unit symbol: vkyb
Elevation: 0 to 3,000 feet
Mean annual precipitation: 45 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Udorthents

Setting

Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Tread, riser
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Parent material: Excavated and filled coarse-loamy human transported material

Typical profile

H1 - 0 to 6 inches: variable
H2 - 6 to 60 inches: variable

Properties and qualities

Slope: 0 to 25 percent
Depth to restrictive feature: More than 80 inches
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.06 to 20.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Hydric soil rating: Unranked

Minor Components

Udorthents,wet substr.

Percent of map unit: 8 percent
Hydric soil rating: Unranked

Udorthents,sandy

Percent of map unit: 8 percent
Hydric soil rating: Unranked

Urban land

Percent of map unit: 4 percent
Hydric soil rating: Unranked

References

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Bioretention Areas & Rain Gardens

Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter.

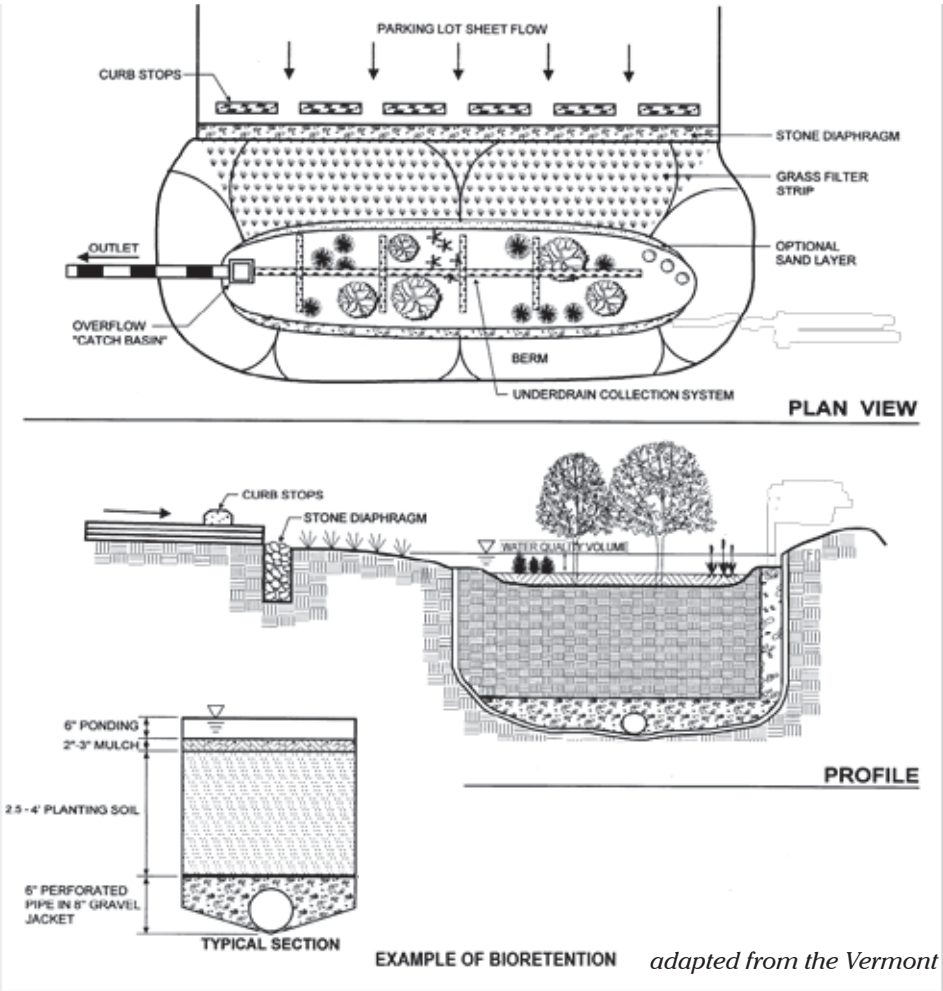
There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	An exfiltrating bioretention area provides groundwater recharge.
4 - TSS Removal	90% TSS removal credit with adequate pretreatment
5 - Higher Pollutant Loading	Can be used for certain land uses with higher potential pollutant loads if lined and sealed until adequate pretreatment is provided. Adequate pretreatment must include 44% TSS removal prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease such as high intensity use parking lots and gas stations, adequate pretreatment may also include an oil grit separator, sand filter or equivalent. In lieu of an oil grit separator or sand filter, a filtering bioretention area also may be used as a pretreatment device for infiltration practices exfiltrating runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.
6 - Discharges near or to Critical Areas	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
7 - Redevelopment	Suitable with appropriate pretreatment

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) — 90% with vegetated filter strip or equivalent
- Total Nitrogen — 30% to 50% if soil media at least 30 inches
- Total Phosphorus — 30% to 90%
- Metals (copper, lead, zinc, cadmium) — 40% to 90%
- Pathogens (coliform, e coli) — Insufficient data



EXAMPLE OF BIORETENTION *adapted from the Vermont Stormwater Manual*

Special Features:

- Can be lined and sealed to prevent recharge where appropriate
- Adequate pretreatment is essential
- Not recommended in areas with steep slope
- Depth of soil media depends on type of vegetation that is proposed
- Soil media must be 30 inches deep to achieve removal of nitrogen

Advantages/Benefits:

- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- Can be used as a stormwater retrofit by modifying existing landscape or if a parking lot is being resurfaced
- Can be used on small lots with space constraints
- Small rain gardens are mosquito death traps
- Little or no hazard for amphibians or other small animals

Disadvantages/Limitations:

- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

Maintenance

Activity	Frequency
Inspect and remove trash	Monthly
Mow	2 to 12 times per year
Mulch	Annually
Fertilize	Annually
Remove dead vegetation	Annually
Prune	Annually

Bioretention Areas & Rain Gardens

Not all bioretention cells are designed to exfiltrate. Only the infiltration requirements are applicable to bioretention cells intended to exfiltrate.

Applicability

Bioretention areas can provide excellent pollutant removal for the "first flush" of stormwater runoff. Properly designed and maintained cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as "rain gardens" and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Bioretention systems can be applied to a wide range of commercial, residential, and industrial developments in many geologic conditions; they work well on small sites and on large sites divided into multiple small drainage areas. Bioretention systems are often well suited for ultra-urban settings where little pervious area exists. Although they require significant space (approximately 5% to 7% of the area that drains to them), they can be integrated into parking lots, parking lot islands, median strips, and traffic islands. Sites can be retrofitted with bioretention areas by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites, they are commonly used for rooftop and driveway runoff.

Effectiveness

Bioretention areas remove pollutants through filtration, microbe activity, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove from 80% to 90% of TSS. If properly designed and installed, bioretention areas remove phosphorus, nitrogen, metals, organics, and bacteria to varying degrees.

Bioretention areas help reduce stress in watersheds that experience severe low flows due to excessive impervious cover. Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe. Decentralized bioretention cells can also reduce the size of storm drain pipes, a major component of stormwater treatment costs. Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide windbreaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Planning Considerations

Filtering bioretention areas are designed with an impermeable liner and underdrain so that the stormwater may be transported to additional BMPs for treatment and/or discharge. Exfiltrating bioretention areas are designed so that following treatment by the bioretention area the stormwater may recharge the groundwater.

Both types of bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads. However, exfiltrating bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads, only if pretreatment has been provided to achieve TSS removal of at least 44%. If the land use has the potential to generate runoff with high concentrations of oil and grease, other types of pretreatment, i.e., a deep sump catch basin and oil grit separator or a sand filter, is required prior to discharge of runoff to an exfiltrating bioretention area. A filtering bioretention area may also be used as a pretreatment device for an exfiltrating bioretention area or other infiltration practice that exfiltrates runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.

To receive 90% TSS removal credit, adequate pretreatment must be provided. If the flow is piped to the bioretention area a deep sump catch catch basin and sediment forebay should be used to provide pretreatment. For sheet flow, there are a number or pretreatment options. These options include:

- A vegetated filter strip, grass channel or water quality swale designed in accordance with the specifications set forth in Chapter 2.
- A grass and gravel combination. This should consist of at least 8 inches of gravel followed by 3 to 5 feet of sod. (source: North Carolina Stormwater Manual, 2007, http://h2o.enr.state.nc.us/su/documents/Ch12-Bioretention_001.pdf)
- Pea diaphragm combined with a vegetated filter strip specially designed to provide pretreatment for a bioretention area as set forth in the following table. (source: Georgia Stormwater Manual and Claytor and Schuler 1996)

Dimensions for Filter Strip Designed Specially to Provide Pretreatment for Bioretention Area

Parameter	Impervious Area				Pervious Areas (lawns, etc.)			
Maximum inflow approach length (feet)	35		75		75		100	
Filter strip slope (max=6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length (feet)	10	15	20	25	10	12	15	18

Bioretention areas must not be located on slopes greater than 20%. When the bioretention area is designed to exfiltrate, the design must ensure vertical separation of at least 2 feet from the seasonal high groundwater table to the bottom of the bioretention cell.

For residential rain gardens, pick a low spot on the property, and route water from a downspout or sump pump into it. It is best to choose a location with full sun, but if that is not possible, make sure it gets at least a half-day of sunlight.

Do not excavate an extensive rain garden under large trees. Digging up shallow feeder roots can weaken or kill a tree. If the tree is not a species that prefers moisture, the additional groundwater could damage it. Size the bioretention area using the methodology set forth in Volume 3.

Design

Size the bioretention area to be 5% to 7% of the area draining to it. Determine the infiltrative capacity of the underlying native soil by performing a soil evaluation in accordance with Volume 3. Do not use a standard septic system (i.e., Title 5) percolation test to determine soil permeability.

The depth of the soil media must be between 2 and 4 feet. This range reflects the fact that most of the pollutant removal occurs within the first 2 feet of soil and that excavations deeper than 4 feet become expensive. The depth selected should accommodate the vegetation. If the minimum depth is used, only shallow rooted plants and grasses my be used. If there is a Total Maximum Daily Load that requires nitrogen to be removed from the stormwater dischrges, the bioretention area should have a soil media with a depth of at least 30 inches, because nitrogen removal takes place 30 inches below the ground surface. If trees and shrubs are to be planted, the soil media should be at least 3 feet.

Size the cells (based on void space and ponding area) at a minimum to capture and treat the required water quality volume (the first 0.5 inch or 1 inch of runoff) if intended to be used for water quality treatment (Stormwater Standard No. 4), the required recharge volume if used for recharge (Stormwater Standard No. 3), or the larger of the two volumes if used to achieve compliance with both Stormwater Standards 3 and 4.

Cover the bottom of the excavation with coarse gravel, over pea gravel, over sand. Earlier designs used filter fabric as a bottom blanket, but more recent experiences show that filter fabric is prone to clogging. Consequently, do not use fabric filters or sand curtains. Use the Engineered Soil Mix below.

Engineered Soil Mix for Bioretention Systems Designed to Exfiltrate

- The soil mix for bioretention areas should be a mixture of sand compost and soil.
  - o 40 % sand,
  - o 20-30% topsoil, and
  - o 30-40% compost.

- The soil mix must be uniform, free of stones, stumps, roots or similar objects larger than 2 inches. Clay content should not exceed 5%.
- Soil pH should generally be between 5.5-6.5, a range that is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants.
- Use soils with 1.5% to 3% organic content and maximum 500-ppm soluble salts.
- The sand component should be gravelly sand that meets ASTM D 422.

Sieve Size	Percent Passing
2-inch	100
¾-inch	70-100
¼-inch	50-80
U.S. No. 40	15-40
U.S. No. 200	0-3

- The topsoil component shall be a sandy loam, loamy sand or loam texture.
- The compost component must be processed from yard waste in accordance with MassDEP Guidelines (see http://www.mass.gov/dep/recycle/reduce/leafguid.doc). The compost shall not contain biosolids.

On-site soil mixing or placement is not allowed if soil is saturated or subject to water within 48 hours. Cover and store soil to prevent wetting or saturation.

Test soil for fertility and micro-nutrients and, only if necessary, amend mixture to create optimum conditions for plant establishment and early growth.

Grade the area to allow a ponding depth of 6 to 8 inches; depending on site conditions, more or less ponding may be appropriate.

Cover the soil with 2 to 3 inches of fine-shredded hardwood mulch.

The planting plan shall include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasional saline conditions due to road salt, and extended dry periods. A list of plants that are suitable for bioretention areas can be found at the end of this section. To avoid a monoculture, it is a good practice to include one tree or shrub per 50 square feet of bioretention area, and at least 3 species each of herbaceous perennials and shrubs. Invasive and exotic species are prohibited. The planting plan should also meet any applicable local landscaping requirements.

All exfiltrating bioretention areas must be designed to drain within 72 hours. However, rain gardens are typically designed to drain water within a day and are thus unlikely to breed mosquitoes.

Bioretention cells, including rain gardens, require pretreatment, such as a vegetated filter strip. A stone or pea gravel diaphragm or, even better, a concrete level spreader upstream of a filter strip will enhance sheet flow and sediment removal.
Bioretention cells can be dosed with sheet flow, a surface inlet, or pipe flow. When using a surface inlet, first direct the flow to a sediment forebay. Alternatively, piped flow may be introduced to the bioretention system via an underdrain.

For bioretention cells dosed via sheet flow or surface inlets, include a ponding area to allow water to pond and be stored temporarily while stormwater is exfiltrating through the cell. Where bioretention areas are adjacent to parking areas, allow three inches of freeboard above the ponding depth to prevent flooding.

Most bioretention cells have an overflow drain that allows ponded water above the selected ponding depth to be dosed to an underdrain. If the bioretention system is designed to exfiltrate, the underdrain is not connected to an outlet, but instead terminates in the bioretention cell. If the bioretention area is not designed to exfiltrate, the underdrain is connected to an outlet for discharge or conveyance to additional best management practices.

Construction

During construction, avoid excessively compacting soils around the bioretention areas and accumulating silt around the drain field. To minimize sediment loading in the treatment area, direct runoff to the bioretention area only from areas that are stabilized; always divert construction runoff elsewhere.

To avoid compaction of the parent material, work from the edge of the area proposed as the location of an exfiltrationg bioretention cell. Never direct runoff to the cell until the cell and the contributing drainage areas are fully stabilized.

Place planting soils in 1-foot to 2-foot lifts and compact them with minimal pressure until the desired elevation is reached. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.

Maintenance

Premature failure of bioretention areas is a significant issue caused by lack of regular maintenance. Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately owned cells. Bioretention areas require careful attention while plants are being established

Bioretention Maintenance Schedule

Activity	*Time of Year*	*Frequency*
Inspect & remove trash	Year round	Monthly
Mulch	Spring	Annually
Remove dead vegetation	Fall or Spring	Annually
Replace dead vegetation	Spring	Annually
Prune	Spring or Fall	Annually
Replace entire media & all vegetation	Late Spring/early Summer	As needed*

** Paying careful attention to pretreatment and operation & maintenance can extend the life of the soil media*

and seasonal landscaping maintenance thereafter.

In many cases, a landscaping contractor working elsewhere on the site can complete maintenance tasks. Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.

Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly. Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall).

Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides. Remove invasive species as needed to prevent these species from spreading into the bioretention area. Replace mulch every two years, in the early spring. Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch. A summary of maintenance activities can be found on the previous page.

Because the soil medium filters contaminants from runoff, the cation exchange capacity of the soil media will eventually be exhausted. When the cation exchange capacity of the soil media decreases, change the soil media to prevent contaminants from migrating to the groundwater, or from being discharged via an underdrain outlet. Using small shrubs and plants instead of larger trees will make it easier to replace the media with clean material when needed.

Plant maintenance is critical. Concentrated salts in roadway runoff may kill plants, necessitating removal of dead vegetation each spring and replanting. The operation and maintenance plan must include measures to make sure the plants are maintained. This is particularly true in residential subdivisions, where the operation and maintenance plan may assign each homeowner the legal responsibility to maintain a bioretention cell or rain garden on his or her property. Including the requirement in the property deed for new subdivisions may alert residential property owners to their legal responsibilities regarding the bioretention cells constructed on their lot.

Cold Climate Considerations

Never store snow in bioretention areas. The Operation and Maintenance plan must specify where on-site snow will be stored. All snow dumps must comply with MassDEP's guidance. When bioretention areas are located along roads, care must be taken during plowing operations to prevent snow from being plowed into the bioretention areas. If snow is plowed into the cells, runoff may bypass the cell and drain into downgradient wetlands without first receiving the required water quality treatment, and without recharging the groundwater.

References

Center for Watershed Protection, 2000, Bioretention as a Water Quality Best Management Practice, Article 110 from Watershed Protection Techniques; http://www.cwp.org/Downloads/ELC_PWP110.pdf

Federal Highway Administration , YEAR, Bioretention Fact Sheet, http://www.fhwa.dot.gov/environment/

Low Impact Development Center, 2003, Drainage – Bioretention Specification, http://www.lowimpactdevelopment.org/epa03/biospec.htm

Prince Georges County, 2002, Bioretention Manual, http://www.goprincegeorgescounty.com/der/bioretention.asp

Puget Sound Action Team, 2005, Low Impact Development, Pp. 174 - 184 http://www.psat.wa.gov/Publications/LID_tech_manual05/LID_manual2005.pdf

U.S. Environmental Protection Agency, 1999, Stormwater Technology Fact Sheet, Bioretention, EPA 832-F-99-012, http://www.epa.gov/owm/mtb/biortn.pdf

U.S. Environmental Protection Agency, 2005, National Management Measures to Control Nonpoint Source Pollution from Urban Areas, Publication Number EPA 841-B-05-004, Pp. 5-29 http://www.epa.gov/nps/urbanmm/

University of North Carolina, www.bae.ncsu.edu/topic/bioretention www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Agrostis alba redtop	FAC	Mesic-Xeric	1-2	H	–	H	H	Shade	Grass	2-3'	Fiberous Shallow	Yes	High	–
Andropogon gerardi bluejoint	FAC	Dry Mesic-Mesic	1-2	–	–	–	–	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	–
Andropogon virginicus broomsedge	–	Wet meadow	1-2	L	–			Full sun	Grass	1-3'		Yes	High	Tolerant of fluctuating water levels and drought.
Carex vulpinoidea fox sedge	OBL	Freshwater marsh	2-4	L	–			Sun to partial sun	Grass	2-3.5'	Rhizome	Yes	High	–
Chelone glabra														
Deschampsia caespitosa tufted hairgrass	FACW	Mesic to wet Mesic	2-4	H	–	H	H	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	May become invasive.
Glyceria striata fowl mannagrass, nerved mannagrass	OBL	Freshwater marsh, seeps	1-2	L	–			Partial shade to full shade	Grass	2-4'	Rhizome	Yes	High	–
Hedera helix English Ivy	FACU	Mesic	1-2	–	–	–	H	Sun	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Hibiscus palustris														
Iris kaempferi														

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in wetlands and non-wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Occur almost always in wetlands

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Lobelia siphilitica														
Lotus Corniculatus birdsfoot-trefoil	FAC	Mesic-Xeric	1-2	H	L	H	H	Sun	Grass	2-3'	Fiberous Shallow	Yes	High	Member of the legume family.
Onoclea sensibilis sensitive fern, beadfern	FACW							Shade		1-3.5'			H	
Pachysandra terminalis Japanese pachysandra	FACU	Mesic	1-2	–	–	–	M	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Panicum virgatum switch grass	FAC to FACU	Mesic	2-4	H	–	–	H	Sun or Shade	Grass	4-5'	Fiberous Shallow	Yes	High	Can spread fast and reach height of 6'.
Vinca major large periwinkle	FACU	Mesic	1-2	–	–	–	H	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	Sensitive to soil compaction and pH changes.
Vinca minor common periwinkle	FACU	Mesic	1-2	–	–	–	H	Shade	Evergreen ground cover	–	Fiberous Shallow	No	Low	–
Indian grass														
Little bluestem														
Deer tongue														
Green coneflower														

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in wetlands and non-wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Occur almost always in wetlands

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Aronia arbutifolia (Pyrus arbutifolia) red chokeberry	FACW	Mesic	1-2	H	–	H	M	Sun to partial sun	Deciduous shrub	6-12'	–	Yes	High	Good bank stabilizer. Tolerates drought.
Clethra alnifolia sweet pepperbush	FAC	Mesic to wet Mesic	2-4	H	–	–	H	Sun to partial sun	Ovoid shrub	6-12'	Shallow	Yes	Med	Coastal plain species.
Cornus Stolonifera (Cornus sericea) red osier dogwood	FACW	Mesic-Hydric	2-4	H	H	H	M	Sun or shade	Arching, spreading shrub	8-10'	Shallow	Yes	High	Needs more consistent moisture levels.
Cornus amomum silky dogwood	FAC	Mesic	1-2	L	–	–	M	Sun to partial sun	Broad-leaved	6-12'	–	Yes	High	Good bank stabilizer
Euonymous europaeus spindle-tree	FAC	Mesic	1-2	M	M	M	M	Sun to partial sun	Upright dense oval shrub	10-12'	Shallow	No	No	–
Hamamelis virginiana witch hazel	FAC	Mesic	2-4	M	M	M	M	Sun or shade	Vase-like compact shrub	4-6'	Shallow	Yes	Low	–
Hypericum densiflorum common St. John's wort	FAC	Mesic	2-4	H	M	M	H	Sun	Ovoid shrub	3-6'	Shallow	Yes	Med	–
Ilex glabra inkberry	FACW	Mesic to wet Mesic	2-4	H	H	–	H	Sun to partial sun	Upright dense shrub	6-12'	Shallow	Yes	High	Coastal plain species.
Ilex verticillata winterberry	FACW	Mesic to wet Mesic	2-4	L	M	–	H	Sun to partial sun	Spreading shrub	6-12'	Shallow	Yes	High	–

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in non-wetlands and wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Almost always occur in wetlands.

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Itea virginica tassel-white, Virginia sweetspire	OBL	Mesic	1-2	M	–	–	M	Sun or shade	Broad-leaved, deciduous shrub	6-12'	–	Yes	Low	–
Juniperus communis "compressa" common juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Mounded shrub	3-6'	Deep taproot	No	High	Evergreen
Juniperus horizontalis "Bar Harbor" creeping juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Matted shrub	0-3'	Deep taproot	No	High	Evergreen
Lindera benzoin spicebush	FACW	Mesic to wet Mesic	2-4	H	–	–	H	Sun	Upright shrub	6-12'	Deep	Yes	High	–
Myrica pennsylvanica bayberry	FAC	Mesic	2-4	H	M	M	H	Sun to partial sun	Rounded, compact shrub	6-8'	Shallow	Yes	High	Coastal plain species.
Physocarpus opulifolius ninebark	FAC	Dry Mesic to wet Mesic	2-4	M	–	–	H	Sun	Upright shrub	6-12'	Shallow	Yes	Med	May be difficult to locate.
Viburnum cassinoides northern wild raisin	FACW	Mesic	2-4	H	H	H	H	Sun to partial sun	Rounded, compacted shrub	6-8'	Shallow	Yes	High	–
Viburnum dentatum arrow-wood	FAC	Mesic to wet	2-4	H	H	H	H	Sun to partial sun	Upright, multi-stemmed shrub	8-10'	Shallow	Yes	High	–
Viburnum lentago nannyberry	FAC	Mesic	2-4	H	H	H	H	Sun to partial sun	Upright, mlti-stemmed shrub	8-10'	Shallow	Yes	High	–

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in non-wetlands and wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Almost always occur in wetlands.

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Acer rubrum red maple	FAC	Mesic-Hydric	4-6	H	H	H	H	Partial sun	Single to multi-stem tree	50-70'	Shallow	Yes	High	-
Amelanchier canadensis shadbush	FAC	Mesic	2-4	H	M	-	H	Partial sun	Single to multi-stem tree	35-50'	Shallow	Yes	High	Not recommended for full sun.
Betula nigra river birch	FACW	Mesic-Hydric	4-6	-	M	M	H	Partial sun	Single to multi-stem tree	50-75'	Shallow	Yes	High	Not susceptible to bronze birch borer.
Betula populifolia gray birch	FAC	Xeric-Hydric	4-6	H	H	M	H	Partial sun	Single to multi-stem tree	35-50'	Shallow to deep	No	High	Native to New England area.
Fraxinus americana white ash	FAC	Mesic	2-4	M	H	H	H	Sun	Large tree	50-80'	Deep	Yes	Low	-
Fraxinus Pennsylvanica green ash	FACW	Mesic	4-6	M	H	H	H	Partial sun	Large tree	40-65'	Shallow to deep	Yes	Low	-
Ginko biloba Maidenhair tree	FAC	Mesic	2-4	H	H	H	H	Sun	Large tree	50-80'	Shallow to deep	No	Low	Avoid female species-offensive odor from fruit.
Gleditsia triacanthos honeylocust	FAC	Mesic	2-4	H	M	-	M	Sun	Small caopied large tree	50-75'	Shallow to deep variable taproot	Yes	Low	Select thornless variety.
Juniperus virginiana eastern red cedar	FACU	Mesic-Xeric	2-4	H	H	-	H	Sun	Dense single stem tree	50-75'	Taproot	Yes	Very high	Evergreen
Liquidambar styraciflua sweet gum	FAC	Mesic	4-6	H	H	H	M	Sun	Large tree	50-70'	Deep taproot	Yes	High	Edge and perimeter; fruit is a maintenance problem.
Nyssa sylvatica black gum	FACW	Mesic-Hydric	4-6	H	H	H	H	Sun	Large tree	40-70'	Shallow to deep taproot	Yes	High	-

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in non-wetlands and wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Almost always occur in wetlands.

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Platanus acerifolia London plane-tree	FACW	Mesic	2-4	H	–	–	M	Sun	Large tree	70-80'	Shallow	No	Low	Tree roots can heave sidewalks.
Platanus occidentalis sycamore	FACW	Mesic-Hydric	4-6	M	M	M	M	Sun	Large tree	70-80'	Shallow	Yes	Med	Edge and perimeter; fruit is a maintennance problem; tree is also prone to windthrow.
Populus deltoides eastern cottonnwood	FAC	Xeric-Mesic	4-6	H	H	H	L	Sun	Large tree with spreading branches	75-100'	Shallow	Yes	High	Short lived.
Quercus bicolor Swamp white oak	FACW	Mesic to wet Mesic	4-6	H	–	H	H	Sun to partial sun	Large tree	75-100'	Shallow	Yes	High	One of the faster growing oaks.
Quercus coccinea scarlet oak	FAC	Mesic	1-2	H	M	M	M	Sun	Large tree	50-75'	Shallow to deep	Yes	High	–
Quercus macrocarpa bur oak	FAC	Mesic to wet Mesic	2-4	H	H	H	M	Sun	Large spreading tree	75-100"	Taproot	No	High	Native to Midwest.
Quercus palustris pin oak	FACW	Mesic-Hydric	4-6	H	H	H	M	Sun	Large tree	60-80'	Shallow to deep taproot	Yes	High	–
Quercus phellos willow oak	FACW	Mesic to wet Mesic	4-6	H	–	–	H	Sun	Large tree	55-75'	Shallow	Yes	High	Fast growing oak.
Quercus rubra red oak	FAC	Mesic	2-4	M	H	M	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	Yes	High	–
Quercus shumardii Shumard's red oak	FAC	Mesic	2-4	H	H	H	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	No	High	Native to Southeast.

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in non-wetlands and wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Almost always occur in wetlands.

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
Scientific Name Common Name	Indicator Status	Habitat	Ponding (days)	Salt	Oil/ Grease	Metals	Insects/ Disease	Exposure	Form	Height	Root System	Native	Wildlife	
Sophora japonica Japanese pagoda tree	FAC	Mesic	1-2	M	M	_	M	Sun	Shade tree	40-70'	Shallow	No	Low	Fruit stains sidewalk.
Taxodium distichum baid cypress	FACW	Mesic-Hydric	4-6	_	_	M	H	Sun to partial sun	Typically single stem tree	75-100'	Shallow	Yes	Low	Not well documented for planting in urban areas.
Thuja occidentalis arborvitae	FACW	Mesic to wet Mesic	2-4	M	M	M	H	Sun to partial sun	Dense single stem tree	50-75'	Shallow	No	Low	Evergreen
Zelkova serrata Japanese zelkova	FACU	Mesic	1-2	M	M	_	H	Sun	Dense shade tree	60-70'	Shallow	No	Low	Branches can split easily in storms.

H High Tolerance
M Medium Tolerance
L Low Tolerance

FACU Facultative Upland - Usually occur in non-wetlands, however, occasionally found in wetlands.
FAC Facultative - Equally likely to occur in non-wetlands and wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Almost always occur in wetlands.

Adapted from the Prince George's County Design Manual & the Center for Watershed Protection for the use of bioretention in Stormwater Management