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
Revised
October 13, 2020

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

TABLE OF CONTENTS

SUMMARY

This Stormwater Report has been prepared to document compliance with Stormwater Management Standards. The applicant is proposing to redevelop approximately 38,500 sf of an existing 59,048 sf lot. The project consists of razing an existing building and pavement areas and constructing a new 165’ long x 85’ wide building and associated parking areas.

The proposed drainage system consists of a subsurface roof drain system and vegetated filter strip to attenuate runoff from the roof of the proposed building. The proposed redevelopment reduces the impervious coverage by approximately 2,230 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 1, 2, 10, 25, 50, and 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 2-5)
1-year	2.73”	2.35	2.23
2-year	3.22”	2.92	2.70
10-year	4.86”	4.79	4.47
25-year	6.15”	6.24	5.91
50-year	7.43”	7.68	7.34
100-year	8.80”	9.21	8.90

Flow to Southeast Catch Basin and Wetland

Design Storm		Existing Condition 1 PRE	Proposed Condition 1 POST
1-year	2.73”	0.73	0.58
2-year	3.22”	0.93	0.76
10-year	4.86”	1.63	1.38
25-year	6.15”	2.19	1.87
50-year	7.43”	2.73	2.36
100-year	8.80”	3.31	2.87

Subsurface Drainage Structure (7R)

Design Storm		Max El. (ft)	Storage (cf)	Peak Inflow	Outflow (Weir)
1-year	2.73”	199.51	652	0.85	0.83
2-year	3.22”	199.51	652	1.01	1.00
10-year	4.86”	199.52	654	1.53	1.51
25-year	6.15”	199.52	655	1.94	1.92
50-year	7.43”	199.52	655	2.34	2.33
100-year	8.80”	199.53	656	2.78	2.76

Section I

Compliance with Massachusetts Stormwater Management Regulations

STANDARD 1. NO NEW STORMWATER CONVEYANCES

The proposed redevelopment proposes no new stormwater conveyances that discharge untreated stormwater off-site or cause down gradient erosion. The proposed redevelopment reduces the impervious coverage by 2,230 sf, therefore reducing runoff. Currently the there is no stormwater treatment for the roof runoff from the existing building. The proposed redevelopment includes a subsurface drainage structure, level spreader, and vegetated filter strip to treat runoff from the proposed building.

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. The proposed redevelopment reduces the impervious coverage by 2,230 sf, therefore reducing runoff. Currently the there is no stormwater treatment for the roof runoff from the existing building. The proposed redevelopment includes a subsurface drainage structure, level spreader, and vegetated filter strip to treat runoff from the proposed building.

STANDARD 3. STORMWATER RECHARGE

Loss of annual recharge to ground water shall be eliminated or minimized through the use of infiltration measures, including environmentally sensitive site design, low impact development techniques, best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from the pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusettss Stormwater Handbook.

The redevelopment design meets Standard 3, comparing post-development to pre-development conditions. Currently there is no annual recharge of stormwater on the existing developed site. The proposed re-development consists of a subsurface drainage structure providing 357 cubic feet of recharge (below the outlet). The annual recharge of the post-developed site exceeds the annual recharge from the pre-developed site. In addition, the proposed development reduces the impervious pavement by 2,230 sf. Since the redevelopment is located within existing paved and building areas, and the redevelopment reduces the impervious pavement, the proposed building area is being used to calculate the recharge volume

Based on Plymouth County Soil Survey, and soils testing conducted onsite, it was determined that the site consists of Hydrologic Soils Group “Type B”.

TABLE 1

REQUIRED RECHARGE VOLUME AND DRAWDOWN

Impervious Area = 14,025 SF
Target Depth Factor (F) = 0.35”

Rv = F x impervious area = 0.35”x 14,025 SF x 1’/12”= 409.5 CF

Total Required Recharge =409.5 CF

Proposed:
Subsurface Drainage Structure
(below level spreader outlet weir elevation 199.50) = 649 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

Subsurface Structure (Pond 7R)

According to the HydroCAD 72 drawdown calculations the structure will fully drain withing 36.10 hours < 72 hour requirement.

See HydroCAD report.

Hydrograph for Pond 7R: Subsurface Structure

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)	Discarded (cfs)	Primary (cfs)
0.10	0.00	0	197.70	0.00	**0.00**	0.00
2.10	0.02	6	197.72	0.02	**0.02**	0.00
4.10	0.03	70	197.95	0.02	0.02	0.00
6.10	0.04	220	198.40	0.02	0.02	0.00
8.10	0.07	513	199.02	0.02	0.02	0.00
10.10	**0.14**	**649**	**199.50**	**0.14**	0.02	**0.12**
12.10	**2.72**	**656**	**199.53**	**2.72**	0.02	**2.71**
14.10	0.14	649	199.50	0.14	0.02	0.12
16.10	0.07	649	199.50	0.07	0.02	0.06
18.10	0.05	649	199.50	0.05	0.02	0.03
20.10	0.04	649	199.50	0.04	0.02	0.02
22.10	0.03	649	199.50	0.03	0.02	0.01
24.10	0.01	648	199.50	0.02	0.02	0.00
26.10	0.00	529	199.07	0.02	0.02	0.00
28.10	0.00	410	198.79	0.02	0.02	0.00
30.10	0.00	290	198.54	0.02	0.02	0.00
32.10	0.00	170	198.28	0.02	0.02	0.00
34.10	0.00	50	197.88	0.02	0.02	0.00
36.10	0.00	0	197.70	0.00	0.00	0.00
38.10	0.00	0	197.70	0.00	0.00	0.00
40.10	0.00	0	197.70	0.00	0.00	0.00
42.10	0.00	0	197.70	0.00	0.00	0.00
44.10	0.00	0	197.70	0.00	0.00	0.00
46.10	0.00	0	197.70	0.00	0.00	0.00
48.10	0.00	0	197.70	0.00	0.00	0.00
50.10	0.00	0	197.70	0.00	0.00	0.00
52.10	0.00	0	197.70	0.00	0.00	0.00
54.10	0.00	0	197.70	0.00	0.00	0.00
56.10	0.00	0	197.70	0.00	0.00	0.00
58.10	0.00	0	197.70	0.00	0.00	0.00
60.10	0.00	0	197.70	0.00	0.00	0.00
62.10	0.00	0	197.70	0.00	0.00	0.00
64.10	0.00	0	197.70	0.00	0.00	0.00
66.10	0.00	0	197.70	0.00	0.00	0.00
68.10	0.00	0	197.70	0.00	0.00	0.00
70.10	0.00	0	197.70	0.00	0.00	0.00

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."

See attached groundwater mounding calculation.

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

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = y). For a rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can change the distances from the center of the basin at which water-table aquifer thickness are calculated.
Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. The user MUST click the blue "Re-Calculate Now" button each time ANY of the user-specified inputs are changed otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

use consistent units (e.g. feet & days **or** inches & hours)

Input Values

2.0400	***R***	**Recharge (infiltration) rate (feet/day)**
0.210	**Sy**	**Specific yield, Sy (dimensionless, between 0 and 1)**
9.76	**K**	**Horizontal hydraulic conductivity, Kh (feet/day)***
90.000	**x**	**1/2 length of basin (x direction, in feet)**
2.000	**y**	**1/2 width of basin (y direction, in feet)**
3.000	**t**	**duration of infiltration period (days)**
38.000	**hi(0)**	**initial thickness of saturated zone (feet)**
38.774	**h(max)**	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
0.774	**Δh(max)**	**maximum groundwater mounding (beneath center of basin at end of infiltration period)**

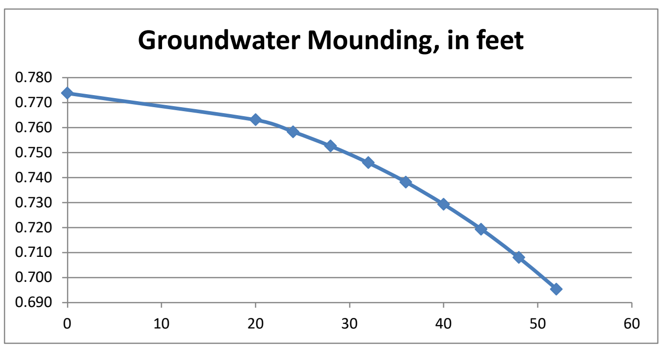
Conversion Table

inch/hour	**feet/day**
0.67	1.33
2.00	4.00
hours	**days**
36	1.50

In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).

Ground-water Mounding, in feet	**Distance from center of basin in x direction, in feet**
0.774	**0**
0.763	**20**
0.758	**24**
0.753	**28**
0.746	**32**
0.738	**36**
0.729	**40**
0.719	**44**
0.708	**48**
0.695	**52**

Re-Calculate Now



Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.

STANDARD 4. WATER QUALITY

TSS Removal

Currently the existing site does not provide any TSS removal for runoff from the existing building. The proposed redevelopment provides TSS removal from roof runoff through a subsurface drainage system and vegetated filter strip. The redevelopment is an improvement of the existing conditions. In addition, pretreatment is not required for roof runoff.

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

V

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

Version 1, Automated: Mar. 4, 2008

TSS Removal Calculation Worksheet

Location: 540 Bodwell Street Ext.

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Subsurface Infiltration Structure	**0.80**	**1.00**	**0.80**	**0.20**
Vegetated Filter Strip >25 feet	**0.10**	**0.20**	**0.02**	**0.18**
	0.00	**0.18**	**0.00**	**0.18**
	0.00	**0.18**	**0.00**	**0.18**
	0.00	**0.18**	**0.00**	**0.18**

Total TSS Removal = 82%

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

Project: 20-067
Prepared By: PS
Date: 6/29/2020

*Equals remaining load from previous BMP (E) which enters the BMP

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

Mass. Dept. of Environmental Protection

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

The redevelopment design meets Standard 4, comparing post-development to pre-development conditions. Currently there is no water quality treatment of stormwater on the existing developed site. The proposed water quality treatment of the post-developed site exceeds treatment conditions from the pre-developed site. In addition, the proposed development reduces the impervious pavement by 2,230 sf. Since the redevelopment is located within existing paved and building areas, and the redevelopment reduces the impervious pavement, the proposed building area is being used to calculate the 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) * (14,025 square feet) = 584 CF

649 CF storage volume provided in the subsurface structure 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 is located within impervious pavement and building areas and reduces the impervious coverage on the site by 2,230 sf. Post development peak rates and volumes have been reduced through the decrease in impervious areas, subsurface drainage structure and vegetated filter strip. The proposed redevelopment is an improvement from the pre-developed conditions.

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

COMMONWEALTH OF MASSACHUSETTS
RICHARD J. GRADY
No. 38072
REGISTERED PROFESSIONAL CIVIL ENGINEER

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:

- ☒ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☒ Reduced Impervious Area (Redevelopment Only)
- ☒ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☐ Use of “country drainage” versus curb and gutter conveyance and pipe
- ☒ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☐ Grass Channel
- ☐ Green Roof
- ☐ Other (describe): ____________________

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☐ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

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

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

---

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

Checklist (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 (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 (continued)

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

- [x] 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
  - [x] 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.

- [x] 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

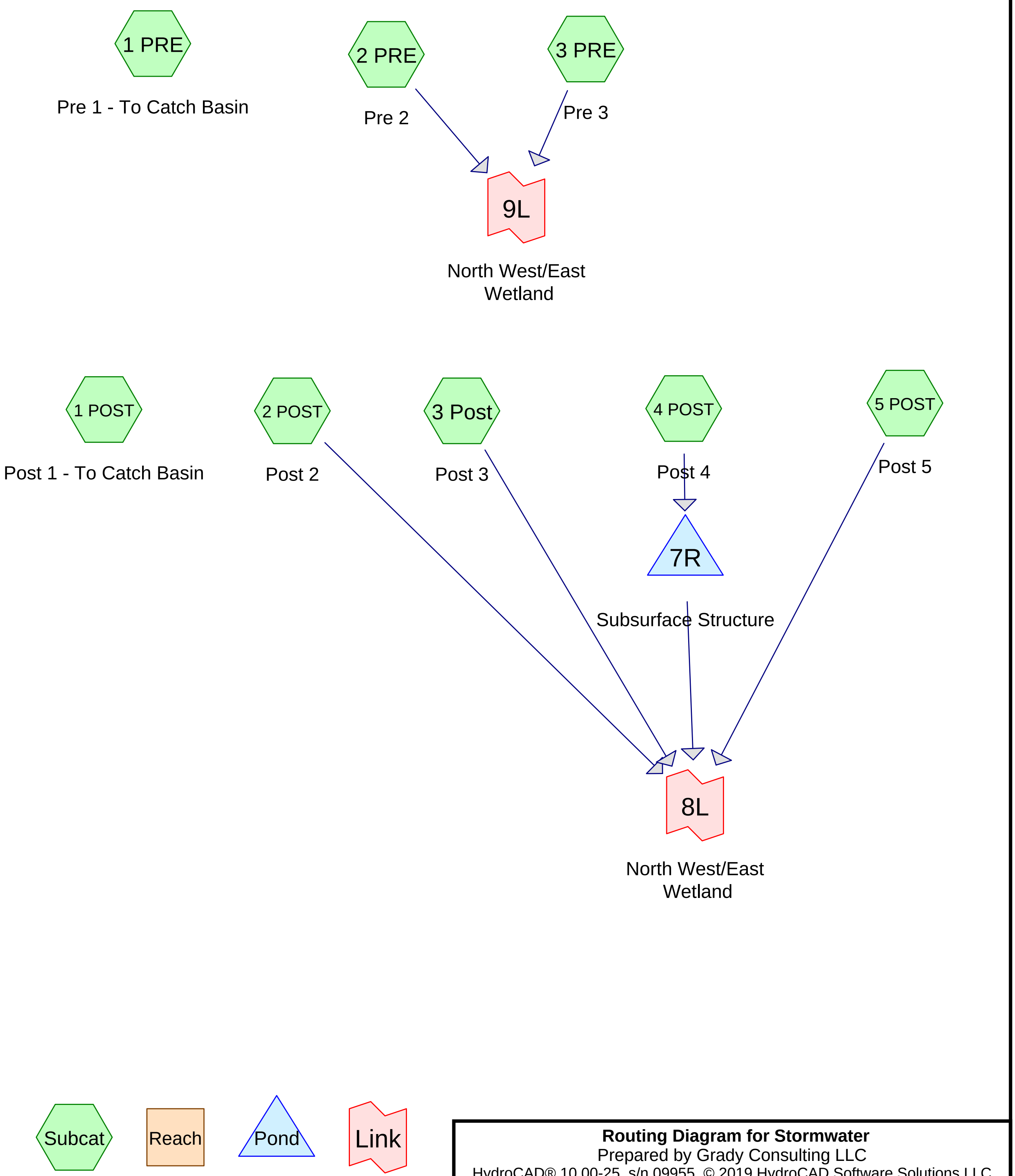
☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ 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



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)
11,727	69	50-75% Grass cover, Fair, HSG B (1 POST, 1 PRE)
6,804	61	>75% Grass cover, Good, HSG B (5 POST)
34,404	96	Gravel surface, HSG B (2 POST, 2 PRE, 3 Post, 3 PRE)
43,584	98	Paved parking, HSG B (1 POST, 1 PRE, 2 POST, 2 PRE, 3 Post, 3 PRE)
6,631	98	Roofs, HSG B (2 PRE)
14,025	98	Unconnected roofs, HSG B (4 POST)
15,001	60	Woods, Fair, HSG B (1 POST, 1 PRE, 2 POST, 2 PRE, 3 Post, 3 PRE, 5 POST)
132,176	**89**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
132,176	HSG B	1 POST, 1 PRE, 2 POST, 2 PRE, 3 Post, 3 PRE, 4 POST, 5 POST
0	HSG C	
0	HSG D	
0	Other	
132,176		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Sub Nur
0	11,727	0	0	0	11,727	50-75% Grass cover, Fair	
0	6,804	0	0	0	6,804	>75% Grass cover, Good	
0	34,404	0	0	0	34,404	Gravel surface	
0	43,584	0	0	0	43,584	Paved parking	
0	6,631	0	0	0	6,631	Roofs	
0	14,025	0	0	0	14,025	Unconnected roofs	
0	15,001	0	0	0	15,001	Woods, Fair	
0	**132,176**	**0**	**0**	**0**	**132,176**	**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 - To Catch Runoff Area=15,970 sf 57.94% Impervious Runoff Depth>1.36"
Tc=6.0 min CN=85 Runoff=0.58 cfs 1,813 cf

Subcatchment 1 PRE: Pre 1 - To Catch Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>1.50"
Tc=6.0 min CN=87 Runoff=0.73 cfs 2,255 cf

Subcatchment 2 POST: Post 2 Runoff Area=17,714 sf 38.51% Impervious Runoff Depth>2.09"
Tc=6.0 min CN=94 Runoff=0.96 cfs 3,082 cf

Subcatchment 2 PRE: Pre 2 Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>1.91"
Tc=6.0 min CN=92 Runoff=1.96 cfs 6,174 cf

Subcatchment 3 Post: Post 3 Runoff Area=8,853 sf 10.22% Impervious Runoff Depth>1.58"
Tc=6.0 min CN=88 Runoff=0.38 cfs 1,165 cf

Subcatchment 3 PRE: Pre 3 Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>1.58"
Tc=6.0 min CN=88 Runoff=0.39 cfs 1,213 cf

Subcatchment 4 POST: Post 4 Runoff Area=14,025 sf 100.00% Impervious Runoff Depth>2.50"
Tc=6.0 min CN=98 Runoff=0.85 cfs 2,919 cf

Subcatchment 5 POST: Post 5 Runoff Area=9,524 sf 0.00% Impervious Runoff Depth>0.27"
Tc=6.0 min CN=61 Runoff=0.03 cfs 213 cf

Pond 7R: Subsurface Structure Peak Elev=199.51' Storage=652 cf Inflow=0.85 cfs 2,919 cf
Discarded=0.02 cfs 1,127 cf Primary=0.87 cfs 1,275 cf Outflow=0.89 cfs 2,402 cf

Link 8L: North West/East Wetland Inflow=2.23 cfs 5,734 cf
Primary=2.23 cfs 5,734 cf

Link 9L: North West/East Wetland Inflow=2.35 cfs 7,387 cf
Primary=2.35 cfs 7,387 cf

Total Runoff Area = 132,176 sf Runoff Volume = 18,833 cf Average Runoff Depth = 1.71"
51.40% Pervious = 67,936 sf 48.60% Impervious = 64,240 sf

Summary for Subcatchment 1 POST: Post 1 - To Catch Basin

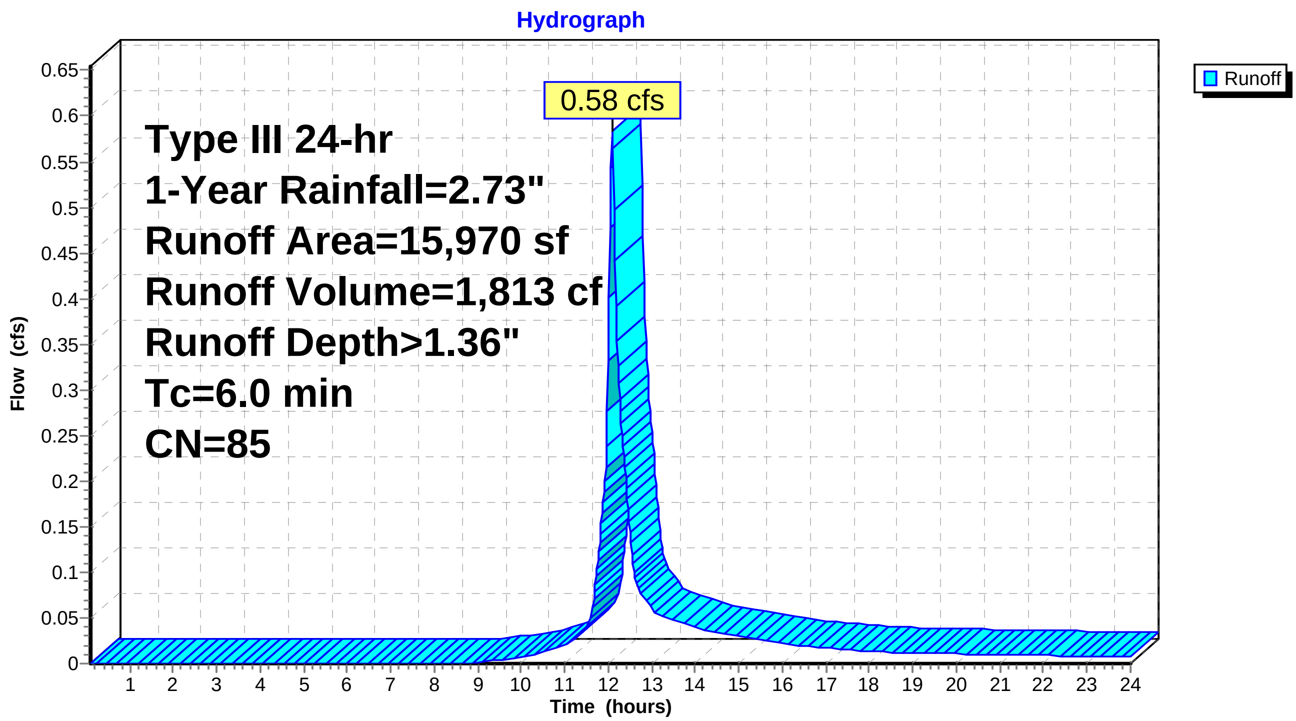
Runoff = 0.58 cfs @ 12.09 hrs, Volume= 1,813 cf, Depth> 1.36"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
5,953	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
9,253	98	Paved parking, HSG B
15,970	85	Weighted Average
6,717		42.06% Pervious Area
9,253		57.94% Impervious Area

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

Subcatchment 1 POST: Post 1 - To Catch Basin



Summary for Subcatchment 1 PRE: Pre 1 - To Catch Basin

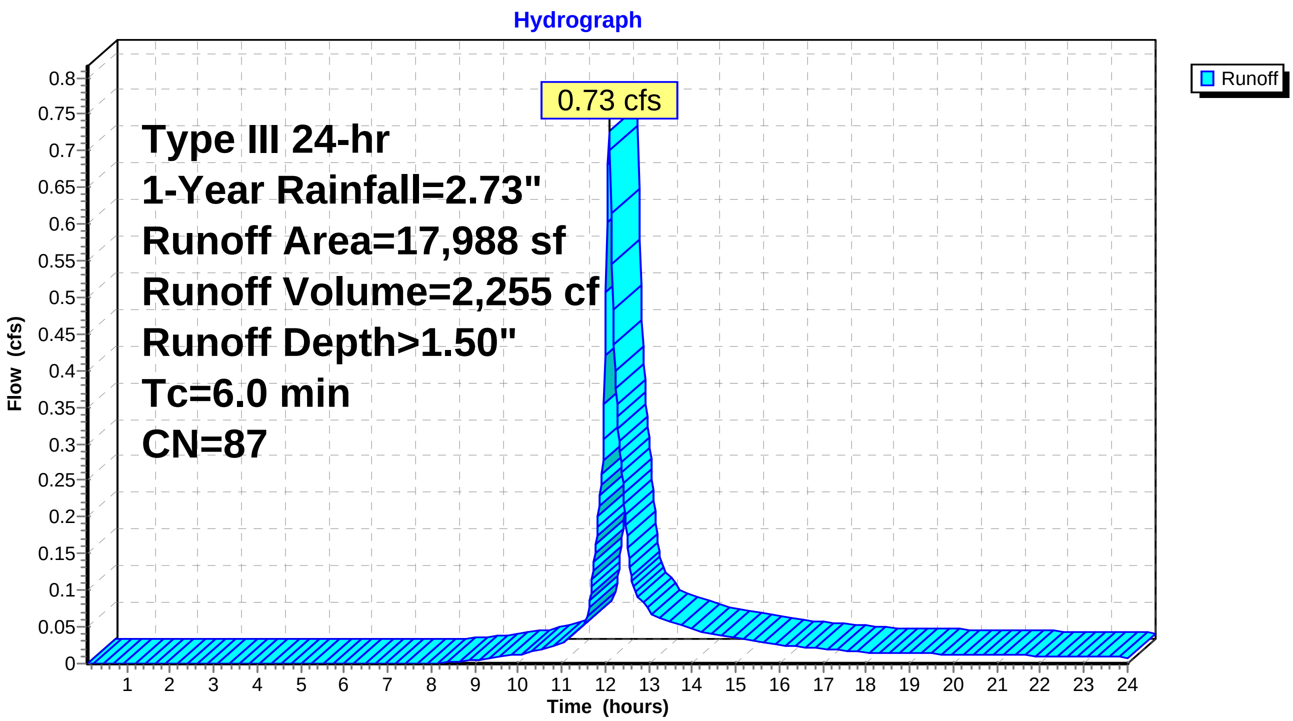
Runoff = 0.73 cfs @ 12.09 hrs, Volume= 2,255 cf, Depth> 1.50"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
5,774	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
11,450	98	Paved parking, HSG B
17,988	87	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
6.0					**Direct Entry,**

Subcatchment 1 PRE: Pre 1 - To Catch Basin



Summary for Subcatchment 2 POST: Post 2

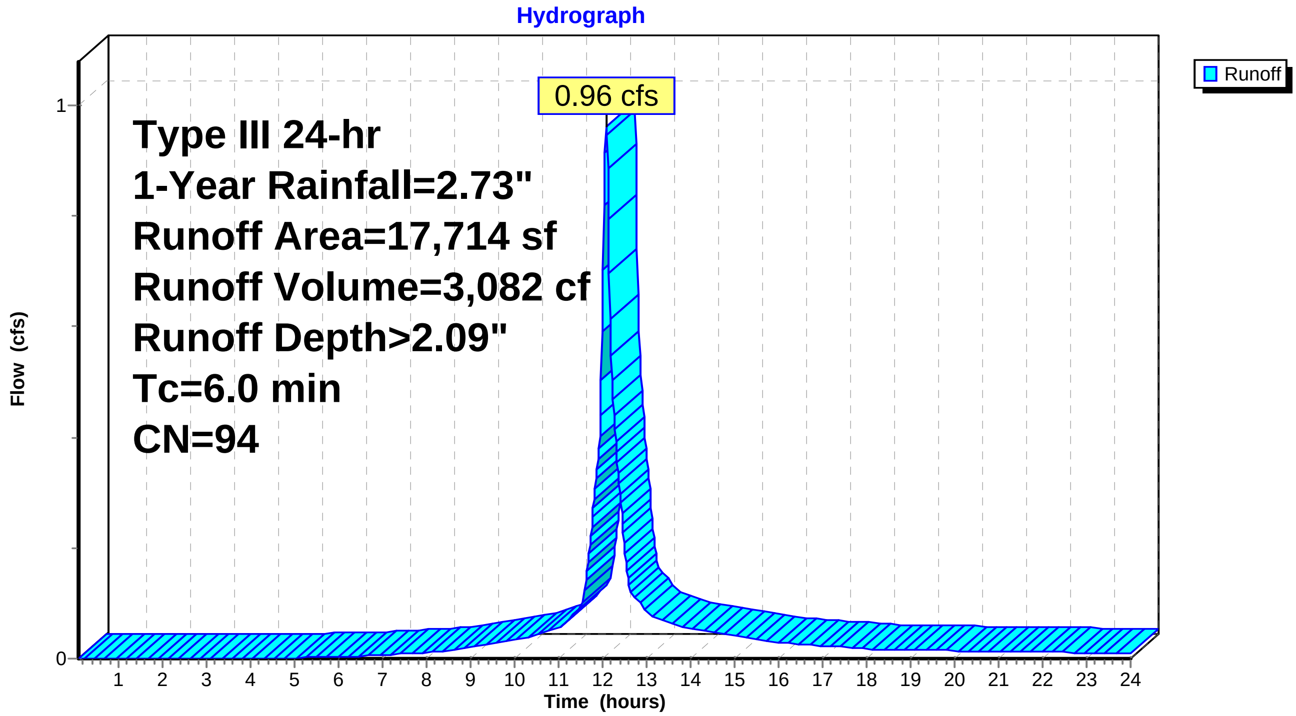
Runoff = 0.96 cfs @ 12.09 hrs, Volume= 3,082 cf, Depth> 2.09"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
1,563	60	Woods, Fair, HSG B
6,822	98	Paved parking, HSG B
9,329	96	Gravel surface, HSG B
17,714	94	Weighted Average
10,892		61.49% Pervious Area
6,822		38.51% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

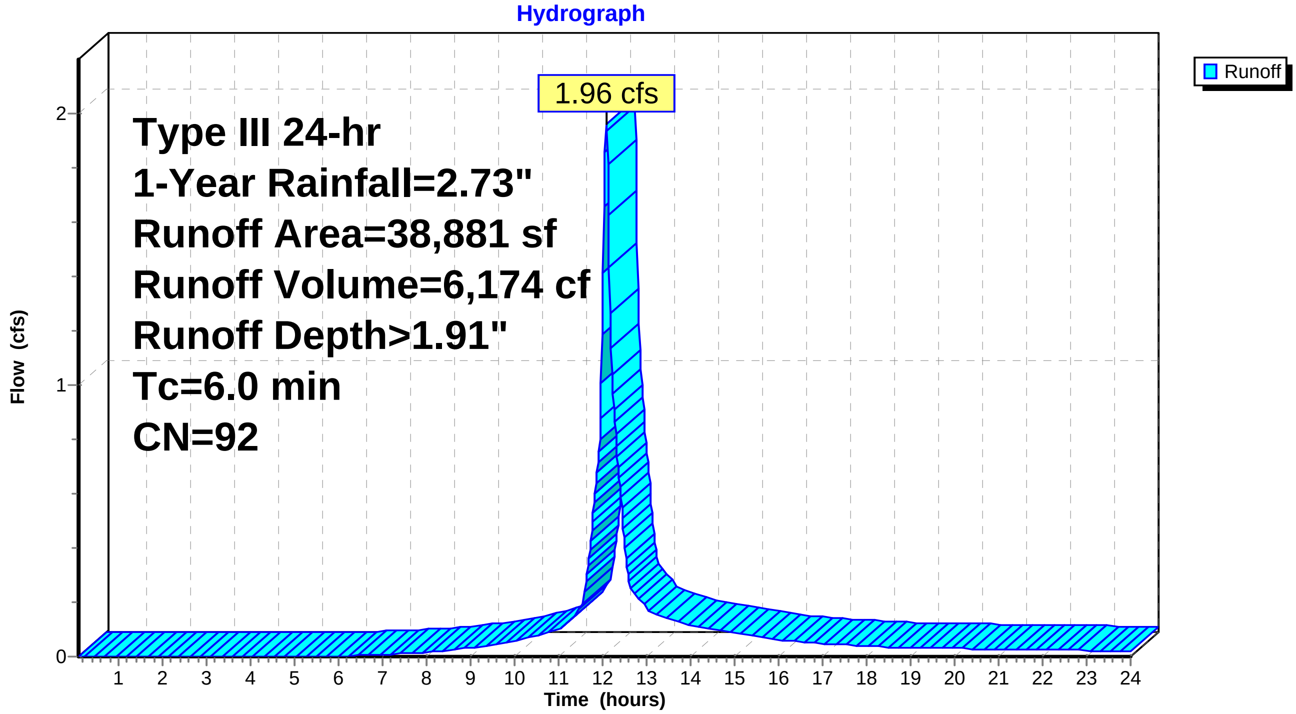
Runoff = 1.96 cfs @ 12.09 hrs, Volume= 6,174 cf, Depth> 1.91"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
4,958	60	Woods, Fair, HSG B
6,631	98	Roofs, HSG B
13,977	98	Paved parking, HSG B
13,315	96	Gravel surface, HSG B
38,881	92	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
6.0					**Direct Entry,**

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

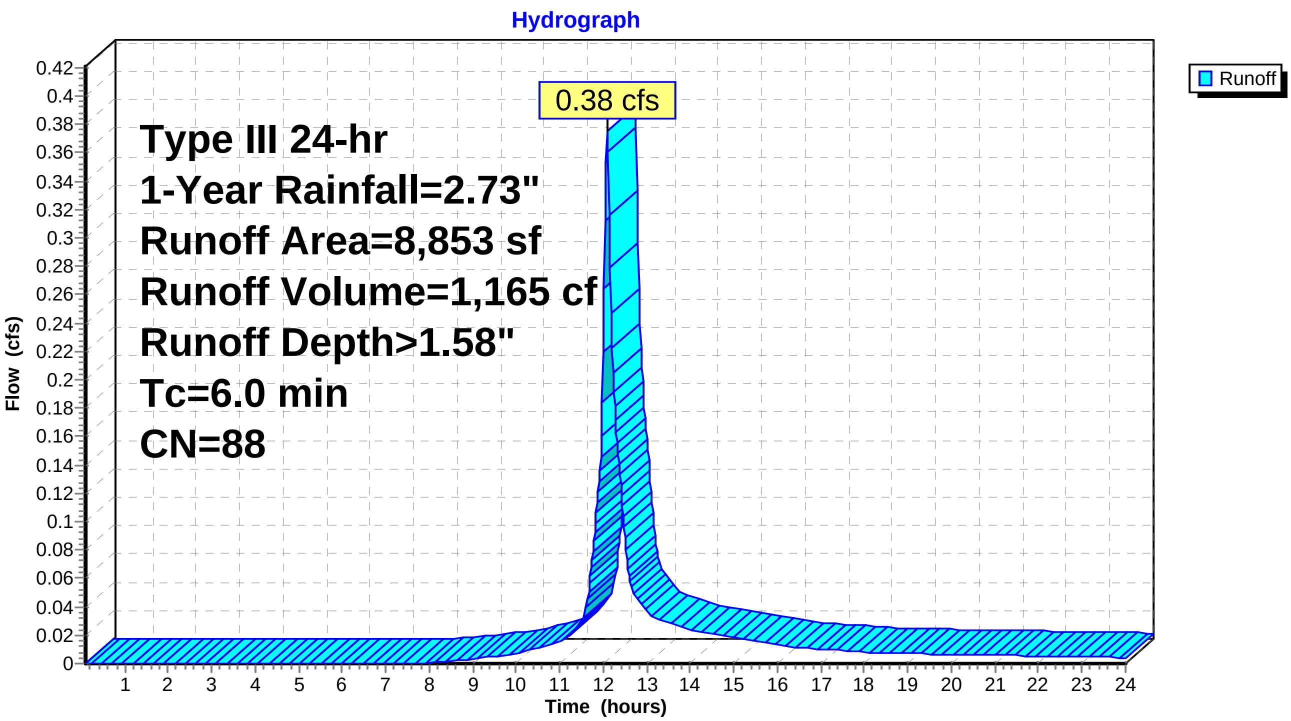
Runoff = 0.38 cfs @ 12.09 hrs, Volume= 1,165 cf, Depth> 1.58"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
5,832	96	Gravel surface, HSG B
905	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
8,853	88	Weighted Average
7,948		89.78% Pervious Area
905		10.22% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

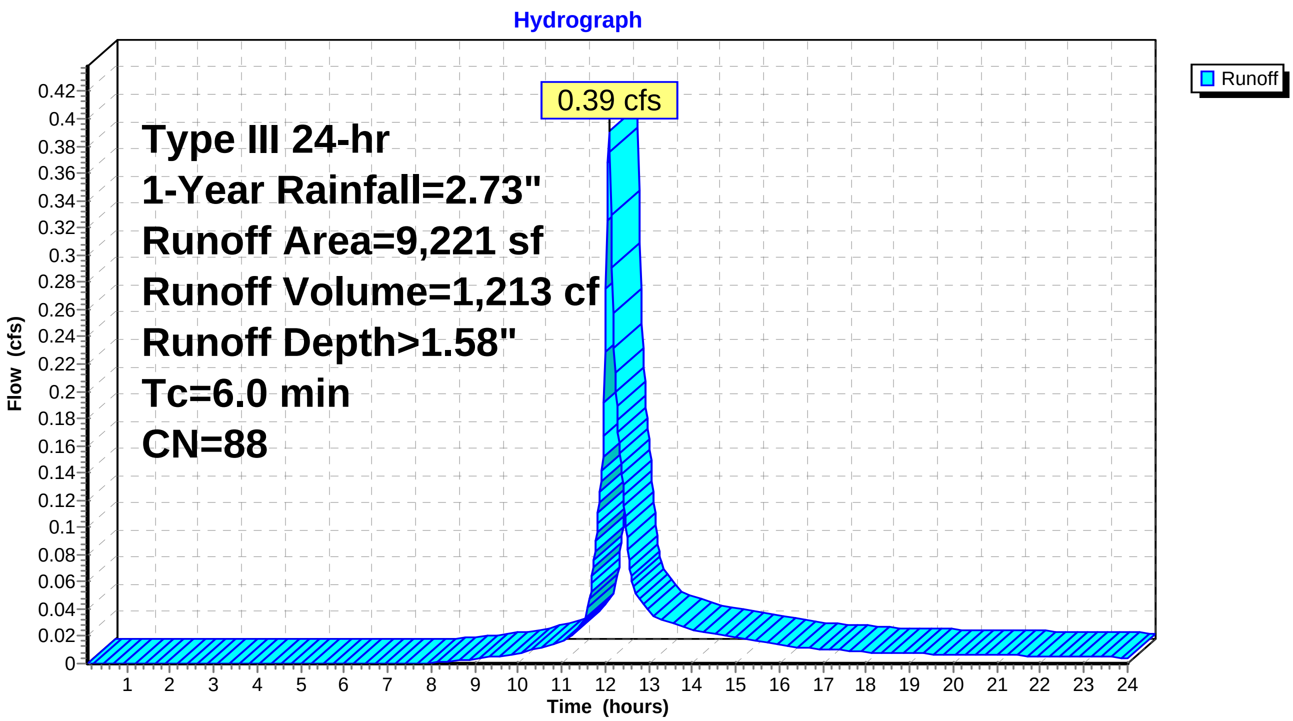
Runoff = 0.39 cfs @ 12.09 hrs, Volume= 1,213 cf, Depth> 1.58"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG B
1,177	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
9,221	88	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
6.0					**Direct Entry,**

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

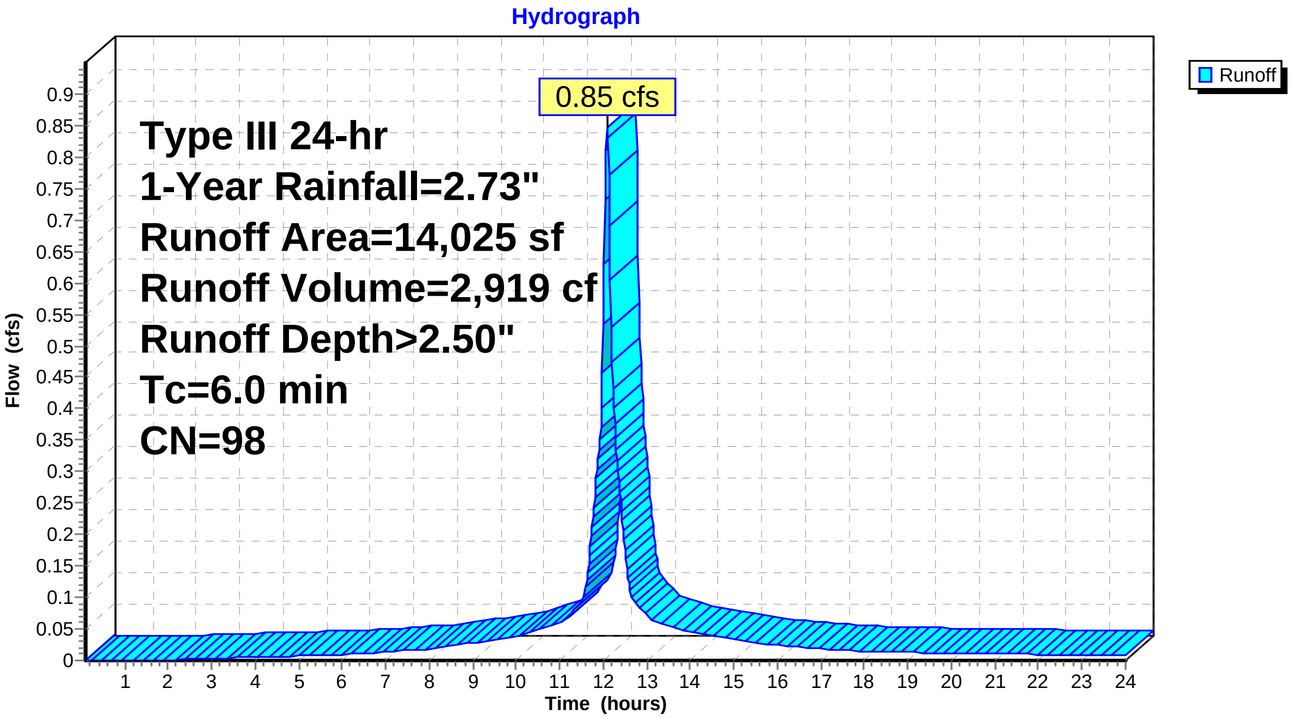
Runoff = 0.85 cfs @ 12.08 hrs, Volume= 2,919 cf, Depth> 2.50"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
14,025	98	Unconnected roofs, HSG B
14,025		100.00% Impervious Area
14,025		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

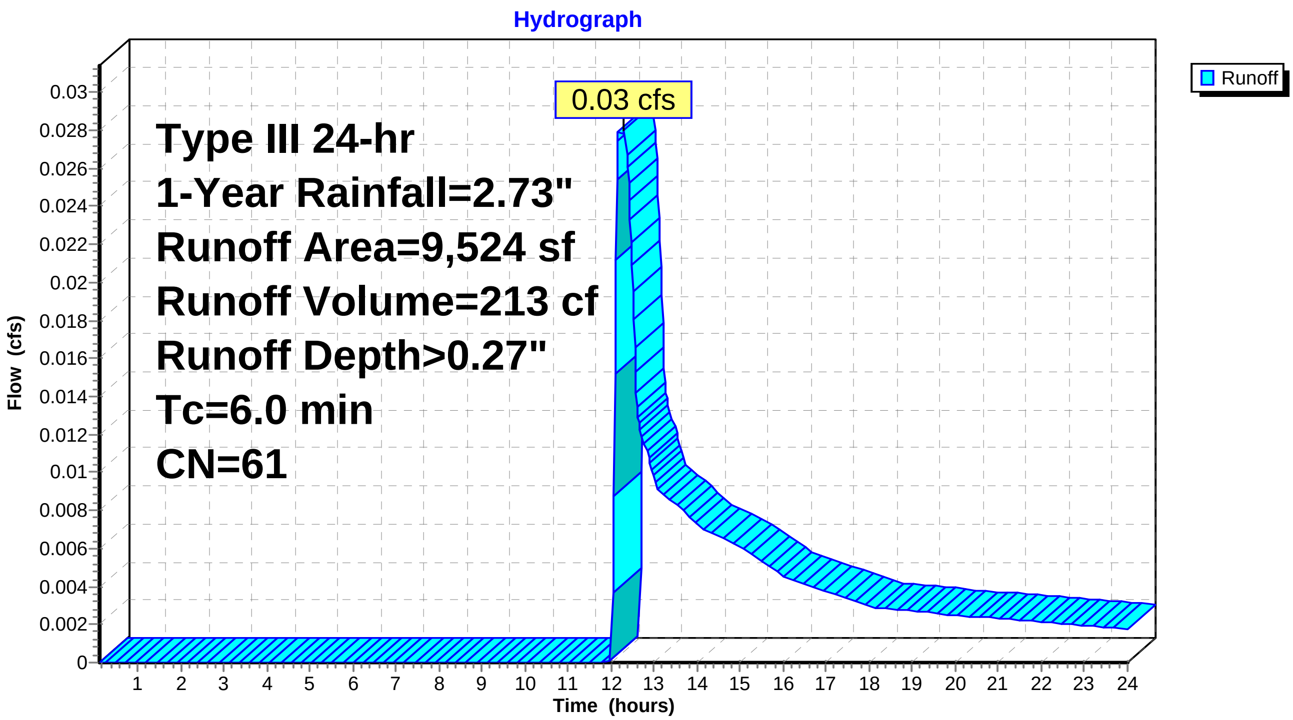
Runoff = 0.03 cfs @ 12.27 hrs, Volume= 213 cf, Depth> 0.27"

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 1-Year Rainfall=2.73"

Area (sf)	CN	Description
6,804	61	>75% Grass cover, Good, HSG B
2,720	60	Woods, Fair, HSG B
9,524	61	Weighted Average
9,524		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Pond 7R: Subsurface Structure

Inflow Area = 14,025 sf,100.00% Impervious, Inflow Depth > 2.50" for 1-Year event
Inflow = 0.85 cfs @ 12.08 hrs, Volume= 2,919 cf
Outflow = 0.89 cfs @ 12.08 hrs, Volume= 2,402 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.02 cfs @ 7.76 hrs, Volume= 1,127 cf
Primary = 0.87 cfs @ 12.08 hrs, Volume= 1,275 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 199.51' @ 12.08 hrs Surf.Area= 705 sf Storage= 652 cf

Plug-Flow detention time= 124.6 min calculated for 2,402 cf (82% of inflow)
Center-of-Mass det. time= 53.9 min (813.2 - 759.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	197.70'	425 cf	**3.92'W x 180.00'L x 2.04'H Field A** 1,440 cf Overall - 377 cf Embedded = 1,063 cf x 40.0% Voids
#2A	198.03'	292 cf	**ADS N-12 12"** x 18 Inside #1 Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf 18 Chambers in 2 Rows
		717 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	197.70'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	199.50'	**180.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 7.76 hrs HW=197.72' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.69 cfs @ 12.08 hrs HW=199.51' (Free Discharge)
↑—**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.69 cfs @ 0.34 fps)

Pond 7R: Subsurface Structure - Chamber Wizard Field A

Chamber Model = ADS N-12 12" (ADS N-12® Pipe)
Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf
Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf

14.5" Wide + 6.0" Spacing = 20.5" C-C Row Spacing

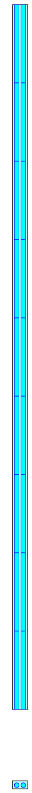
9 Chambers/Row x 20.00' Long = 180.00' Row Length
2 Rows x 14.5" Wide + 6.0" Spacing x 1 + 6.0" Side Stone x 2 = 3.92' Base Width
4.0" Base + 14.5" Chamber Height + 6.0" Cover = 2.04' Field Height

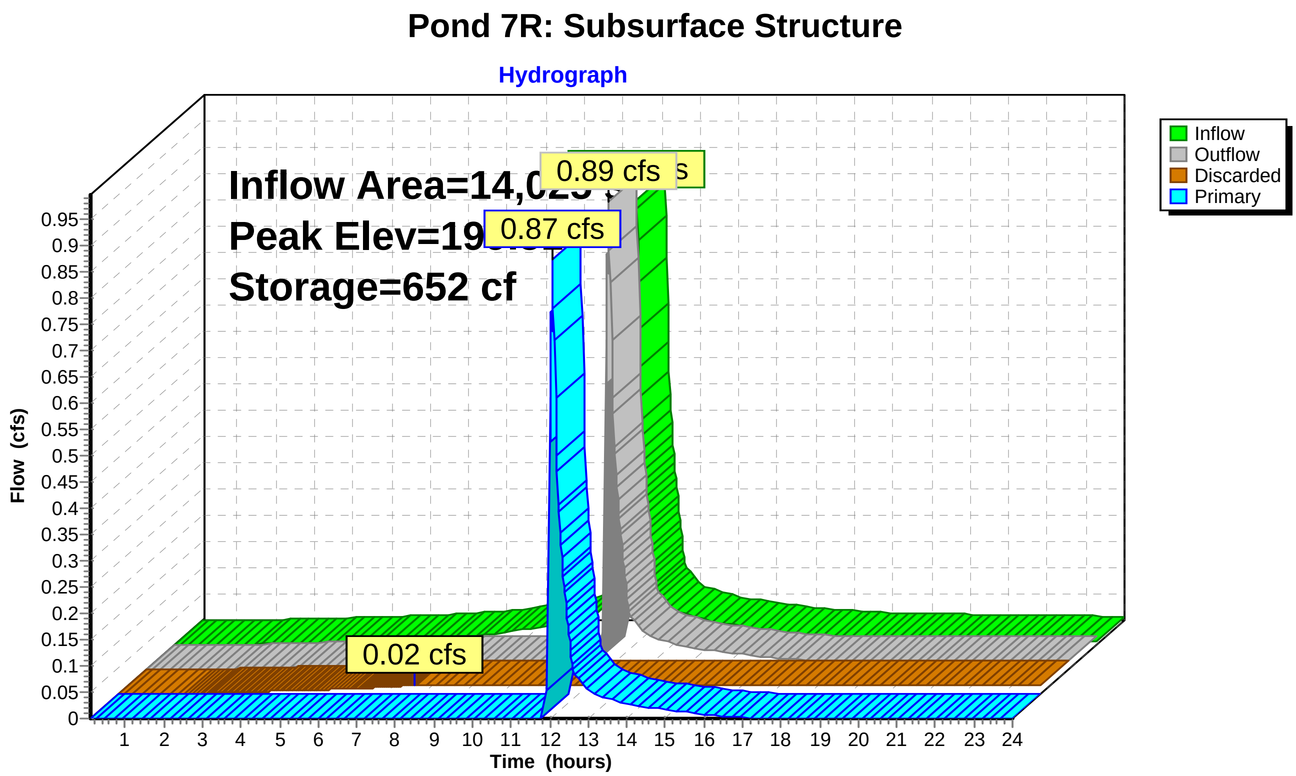
18 Chambers x 16.2 cf = 291.6 cf Chamber Storage
18 Chambers x 20.9 cf = 376.8 cf Displacement

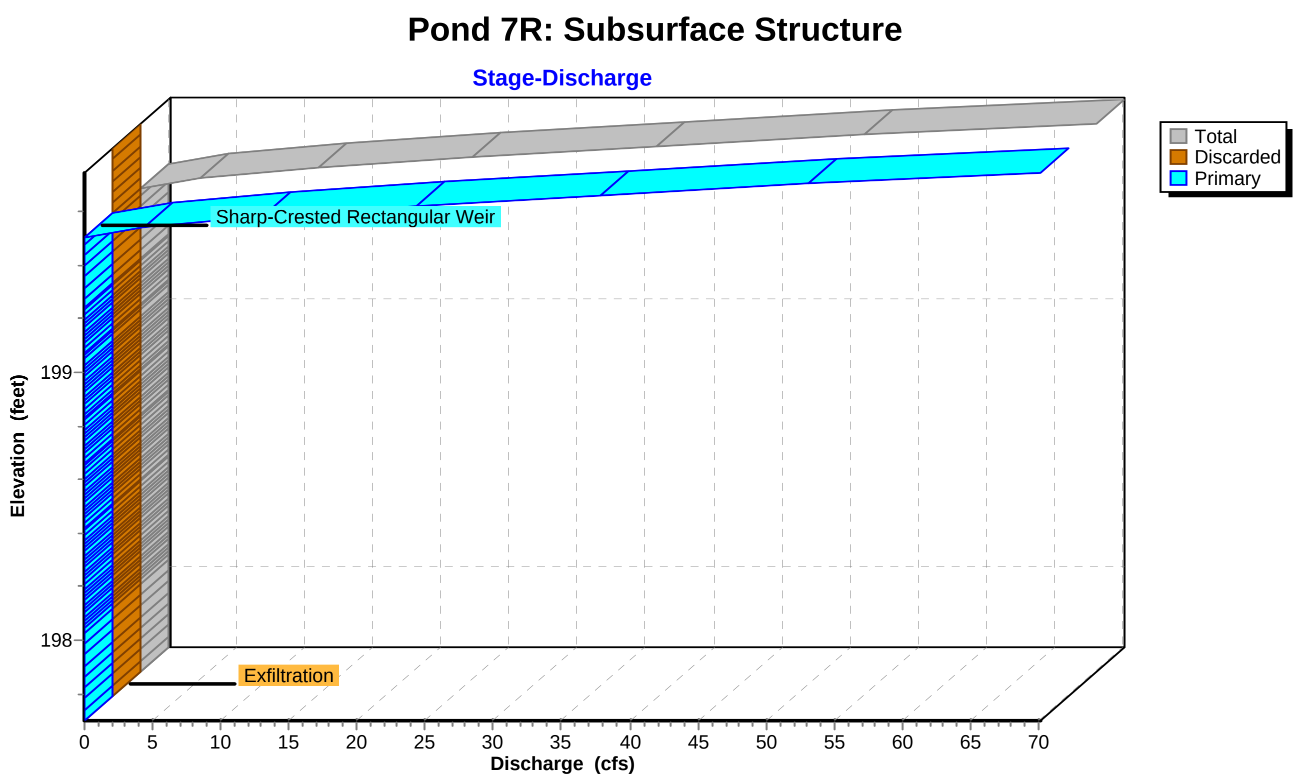
1,440.2 cf Field - 376.8 cf Chambers = 1,063.3 cf Stone x 40.0% Voids = 425.3 cf Stone Storage

Chamber Storage + Stone Storage = 716.9 cf = 0.016 af
Overall Storage Efficiency = 49.8%
Overall System Size = 180.00' x 3.92' x 2.04'

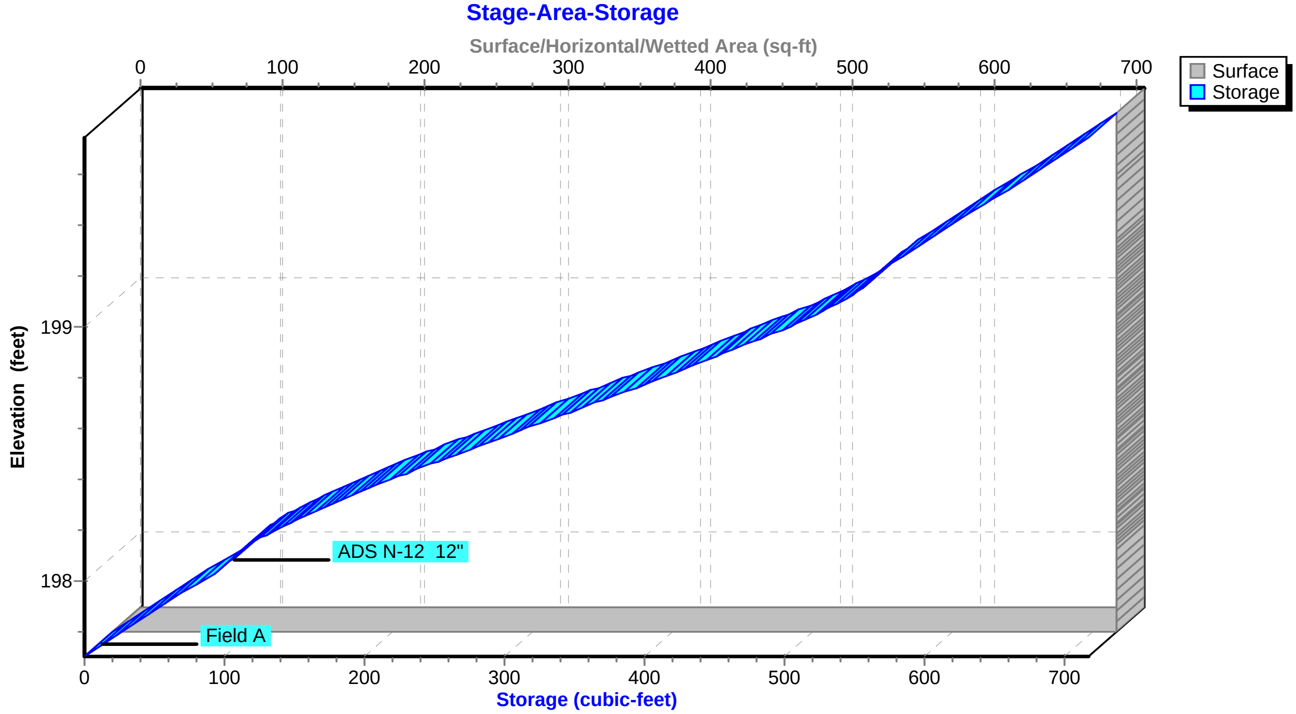
18 Chambers @ $ 0.00 /ea = $ 0.00
53.3 cy Field Excavation @ $ 10.00 /cy = $ 533.39
39.4 cy Stone @ $ 30.00 /cy = $ 1,181.47
Total Cost = $ 1,714.86




Pond 7R: Subsurface Structure
Hydrograph
Inflow Area=14,025 sf
Peak Elev=198.69'
Storage=652 cf
0.89 cfs
0.87 cfs
0.02 cfs
Inflow
Outflow
Discarded
Primary
Flow (cfs)
Time (hours)


Pond 7R: Subsurface Structure
Stage-Discharge
Total
Discarded
Primary
Sharp-Crested Rectangular Weir
Exfiltration
Elevation (feet)
Discharge (cfs)

Pond 7R: Subsurface Structure

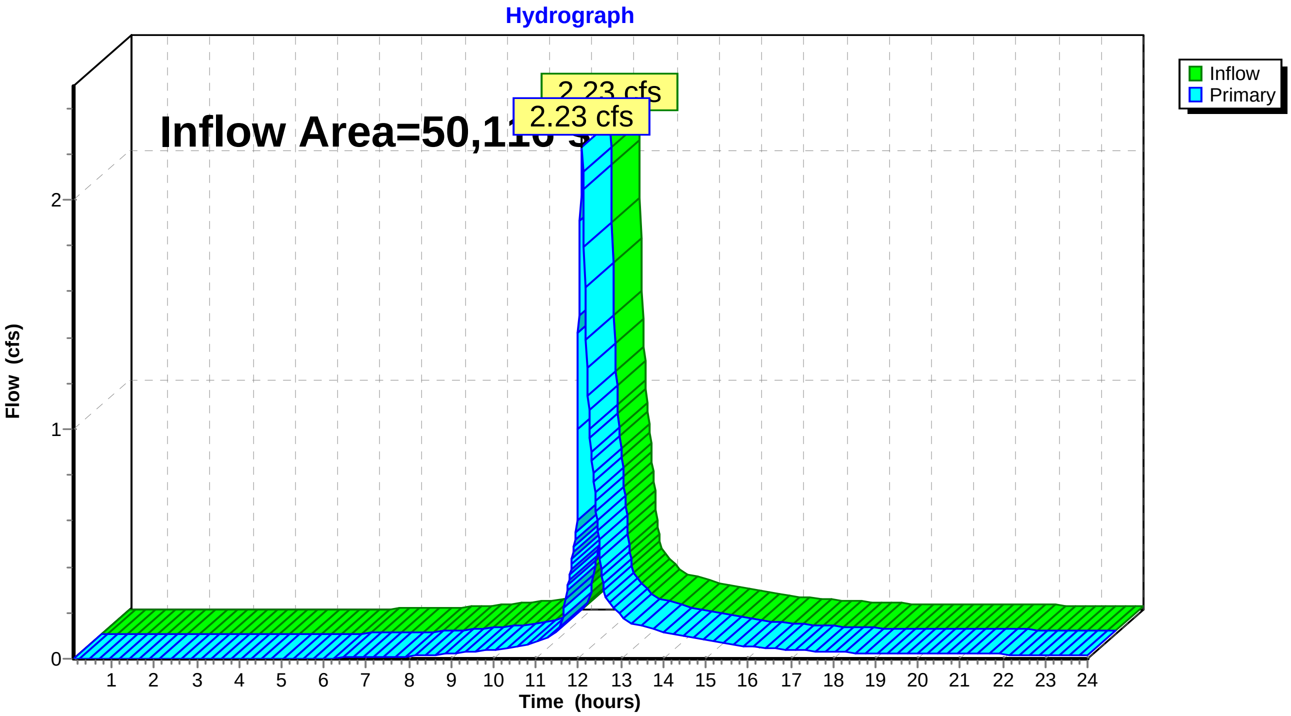


Summary for Link 8L: North West/East Wetland

Inflow Area = 50,116 sf, 43.40% Impervious, Inflow Depth > 1.37" for 1-Year event
Inflow = 2.23 cfs @ 12.08 hrs, Volume= 5,734 cf
Primary = 2.23 cfs @ 12.08 hrs, Volume= 5,734 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

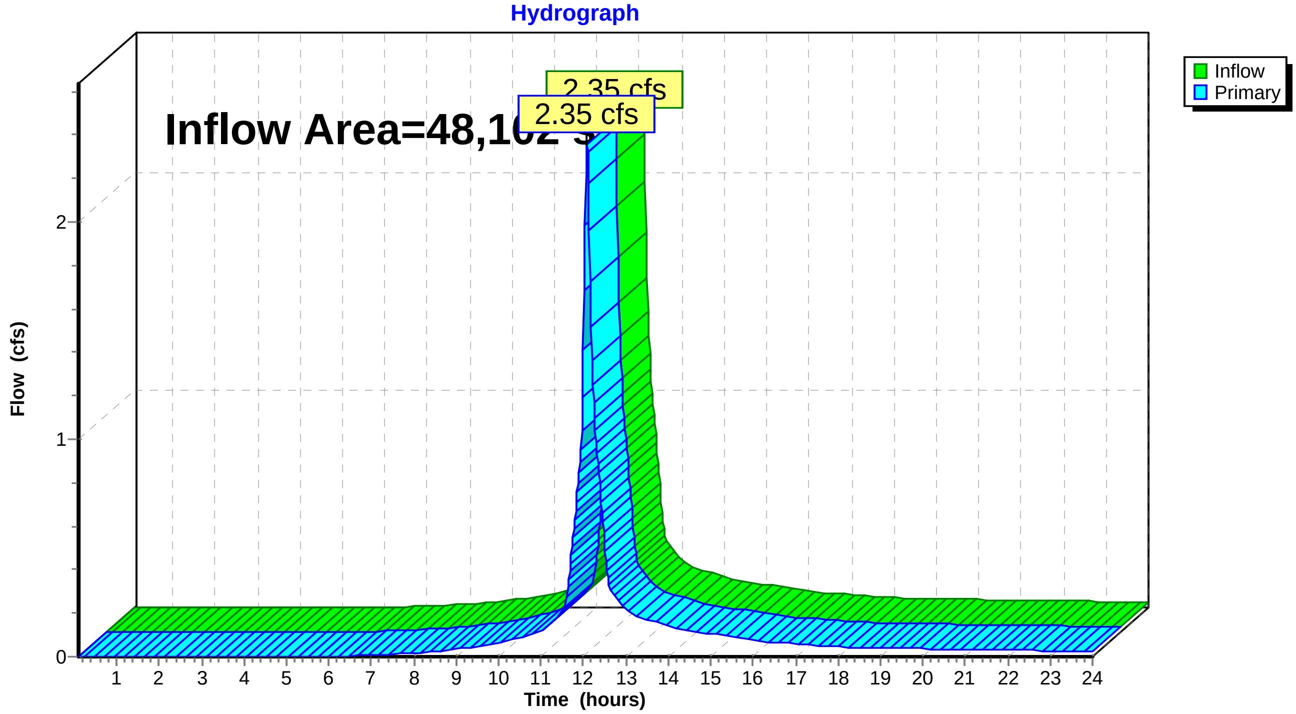


Summary for Link 9L: North West/East Wetland

Inflow Area =	48,102 sf,	45.29% Impervious,	Inflow Depth > 1.84"	for 1-Year event	
Inflow =	2.35 cfs @	12.09 hrs,	Volume=	7,387 cf	
Primary =	2.35 cfs @	12.09 hrs,	Volume=	7,387 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 - To Catch Runoff Area=15,970 sf 57.94% Impervious Runoff Depth>1.77"
Tc=6.0 min CN=85 Runoff=0.76 cfs 2,359 cf

Subcatchment 1 PRE: Pre 1 - To Catch Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>1.93"
Tc=6.0 min CN=87 Runoff=0.93 cfs 2,894 cf

Subcatchment 2 POST: Post 2 Runoff Area=17,714 sf 38.51% Impervious Runoff Depth>2.56"
Tc=6.0 min CN=94 Runoff=1.17 cfs 3,781 cf

Subcatchment 2 PRE: Pre 2 Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>2.37"
Tc=6.0 min CN=92 Runoff=2.42 cfs 7,671 cf

Subcatchment 3 Post: Post 3 Runoff Area=8,853 sf 10.22% Impervious Runoff Depth>2.01"
Tc=6.0 min CN=88 Runoff=0.48 cfs 1,485 cf

Subcatchment 3 PRE: Pre 3 Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>2.01"
Tc=6.0 min CN=88 Runoff=0.50 cfs 1,547 cf

Subcatchment 4 POST: Post 4 Runoff Area=14,025 sf 100.00% Impervious Runoff Depth>2.99"
Tc=6.0 min CN=98 Runoff=1.01 cfs 3,489 cf

Subcatchment 5 POST: Post 5 Runoff Area=9,524 sf 0.00% Impervious Runoff Depth>0.45"
Tc=6.0 min CN=61 Runoff=0.07 cfs 358 cf

Pond 7R: Subsurface Structure Peak Elev=199.51' Storage=652 cf Inflow=1.01 cfs 3,489 cf
Discarded=0.02 cfs 1,170 cf Primary=1.00 cfs 1,758 cf Outflow=1.01 cfs 2,928 cf

Link 8L: North West/East Wetland Inflow=2.70 cfs 7,382 cf
Primary=2.70 cfs 7,382 cf

Link 9L: North West/East Wetland Inflow=2.92 cfs 9,218 cf
Primary=2.92 cfs 9,218 cf

Total Runoff Area = 132,176 sf Runoff Volume = 23,583 cf Average Runoff Depth = 2.14"
51.40% Pervious = 67,936 sf 48.60% Impervious = 64,240 sf

Summary for Subcatchment 1 POST: Post 1 - To Catch Basin

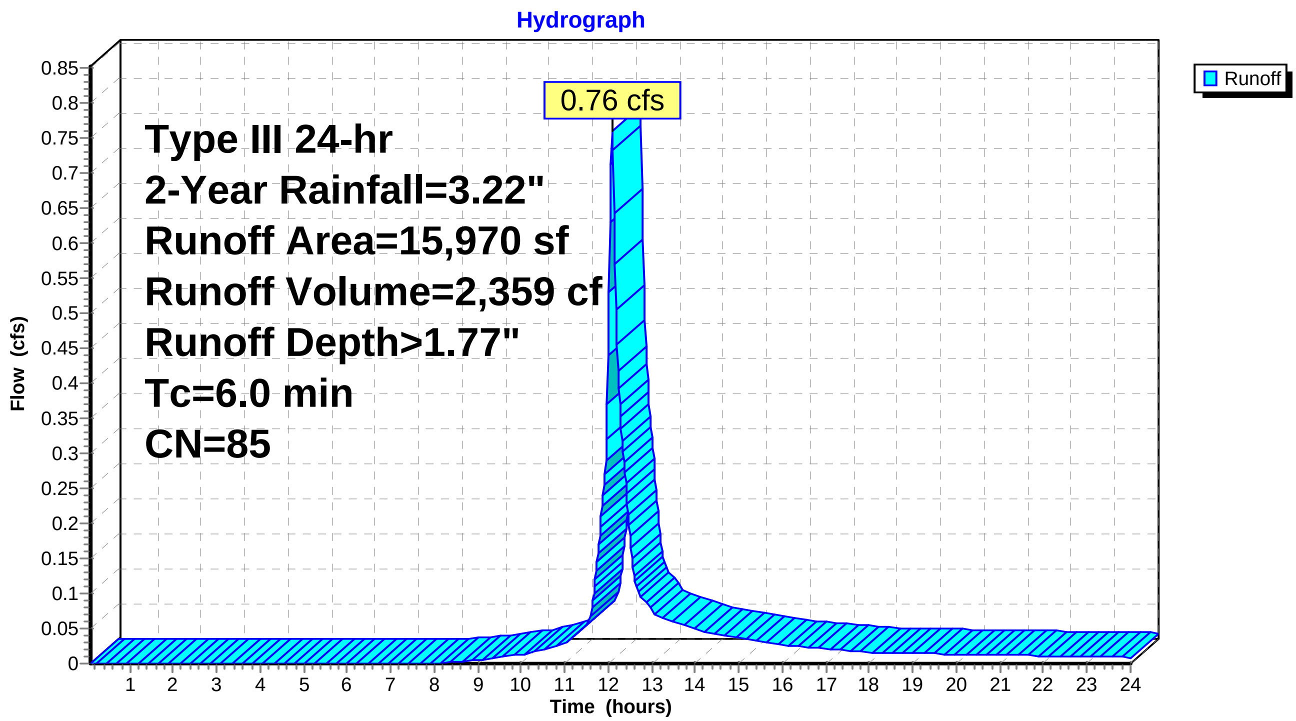
Runoff = 0.76 cfs @ 12.09 hrs, Volume= 2,359 cf, Depth> 1.77"

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=3.22"

Area (sf)	CN	Description
5,953	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
9,253	98	Paved parking, HSG B
15,970	85	Weighted Average
6,717		42.06% Pervious Area
9,253		57.94% Impervious Area

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

Subcatchment 1 POST: Post 1 - To Catch Basin



Summary for Subcatchment 1 PRE: Pre 1 - To Catch Basin

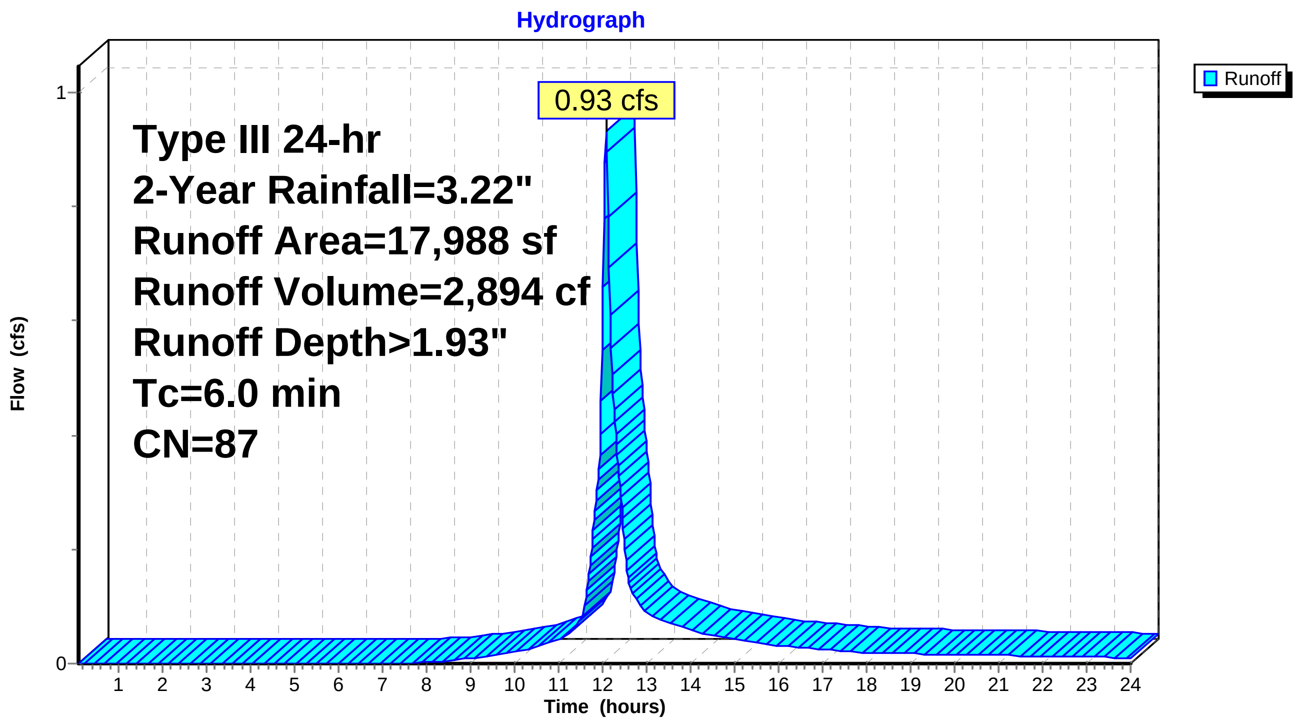
Runoff = 0.93 cfs @ 12.09 hrs, Volume= 2,894 cf, Depth> 1.93"

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 2-Year Rainfall=3.22"

Area (sf)	CN	Description
5,774	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
11,450	98	Paved parking, HSG B
17,988	87	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
6.0					**Direct Entry,**

Subcatchment 1 PRE: Pre 1 - To Catch Basin



Summary for Subcatchment 2 POST: Post 2

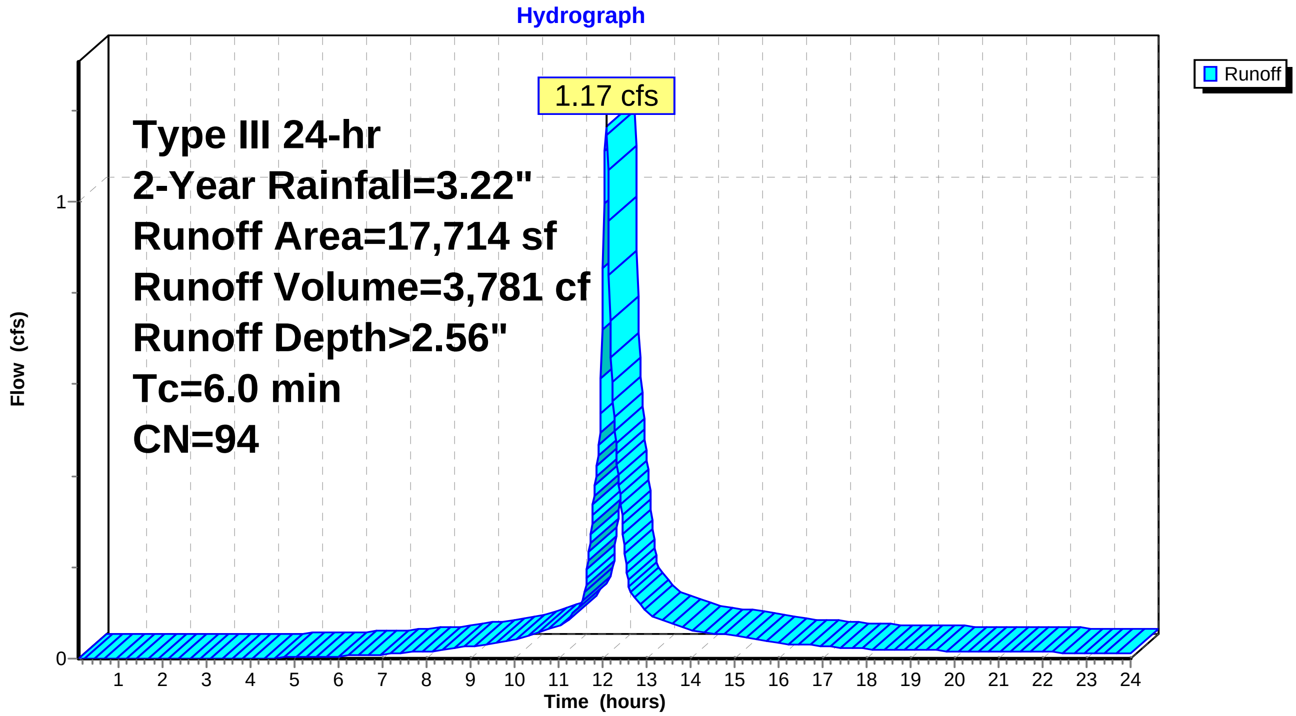
Runoff = 1.17 cfs @ 12.08 hrs, Volume= 3,781 cf, Depth> 2.56"

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 2-Year Rainfall=3.22"

Area (sf)	CN	Description
1,563	60	Woods, Fair, HSG B
6,822	98	Paved parking, HSG B
9,329	96	Gravel surface, HSG B
17,714	94	Weighted Average
10,892		61.49% Pervious Area
6,822		38.51% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

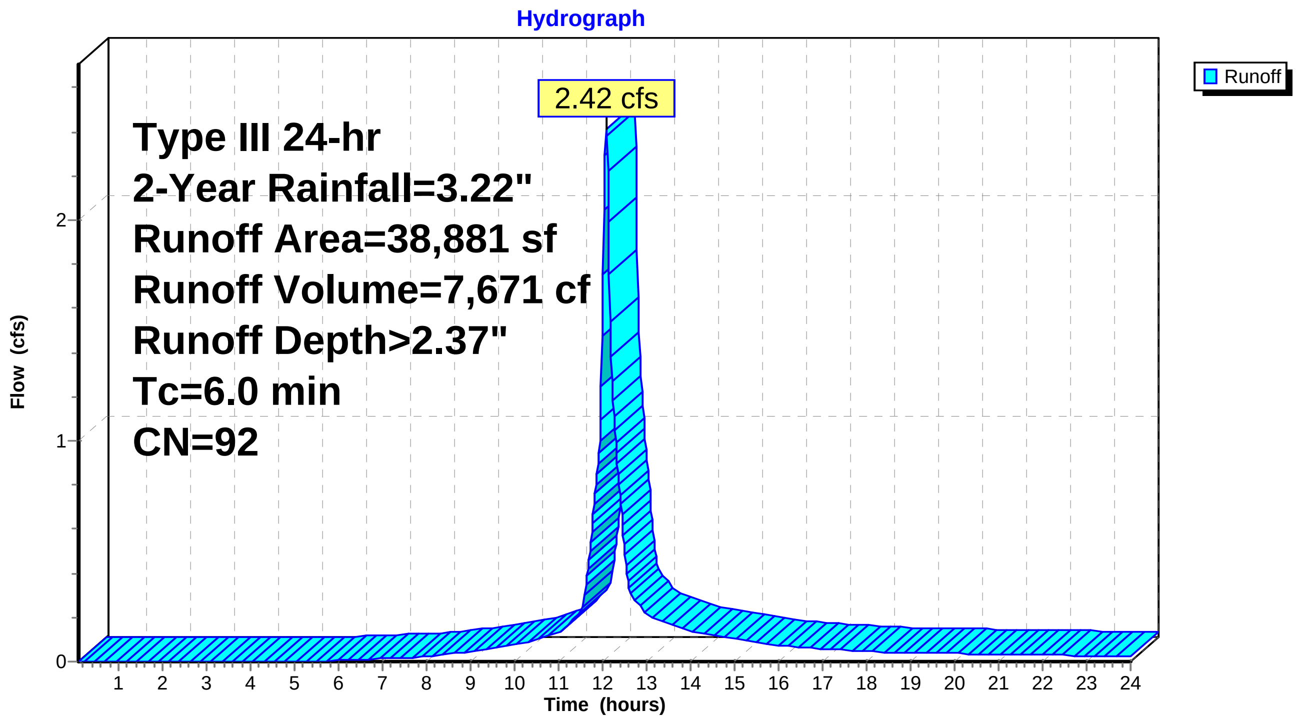
Runoff = 2.42 cfs @ 12.09 hrs, Volume= 7,671 cf, Depth> 2.37"

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=3.22"

Area (sf)	CN	Description
4,958	60	Woods, Fair, HSG B
6,631	98	Roofs, HSG B
13,977	98	Paved parking, HSG B
13,315	96	Gravel surface, HSG B
38,881	92	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
6.0					**Direct Entry,**

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

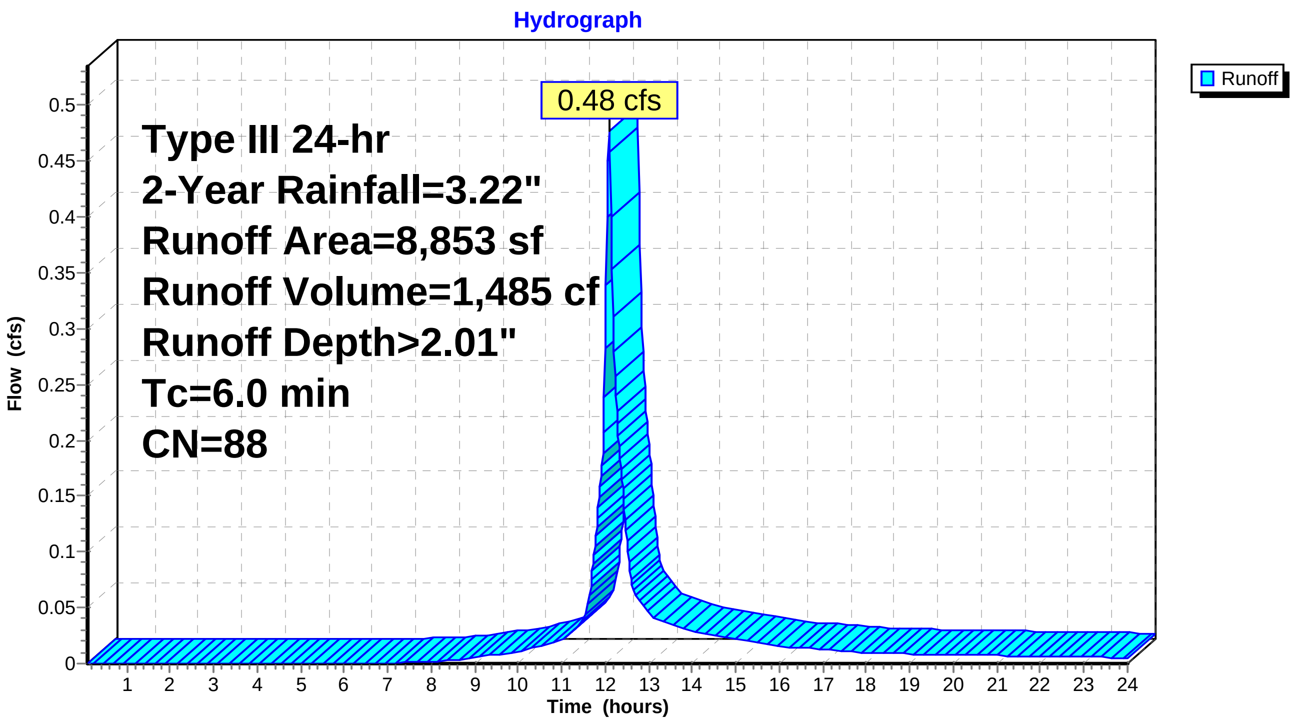
Runoff = 0.48 cfs @ 12.09 hrs, Volume= 1,485 cf, Depth> 2.01"

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 2-Year Rainfall=3.22"

Area (sf)	CN	Description
5,832	96	Gravel surface, HSG B
905	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
8,853	88	Weighted Average
7,948		89.78% Pervious Area
905		10.22% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

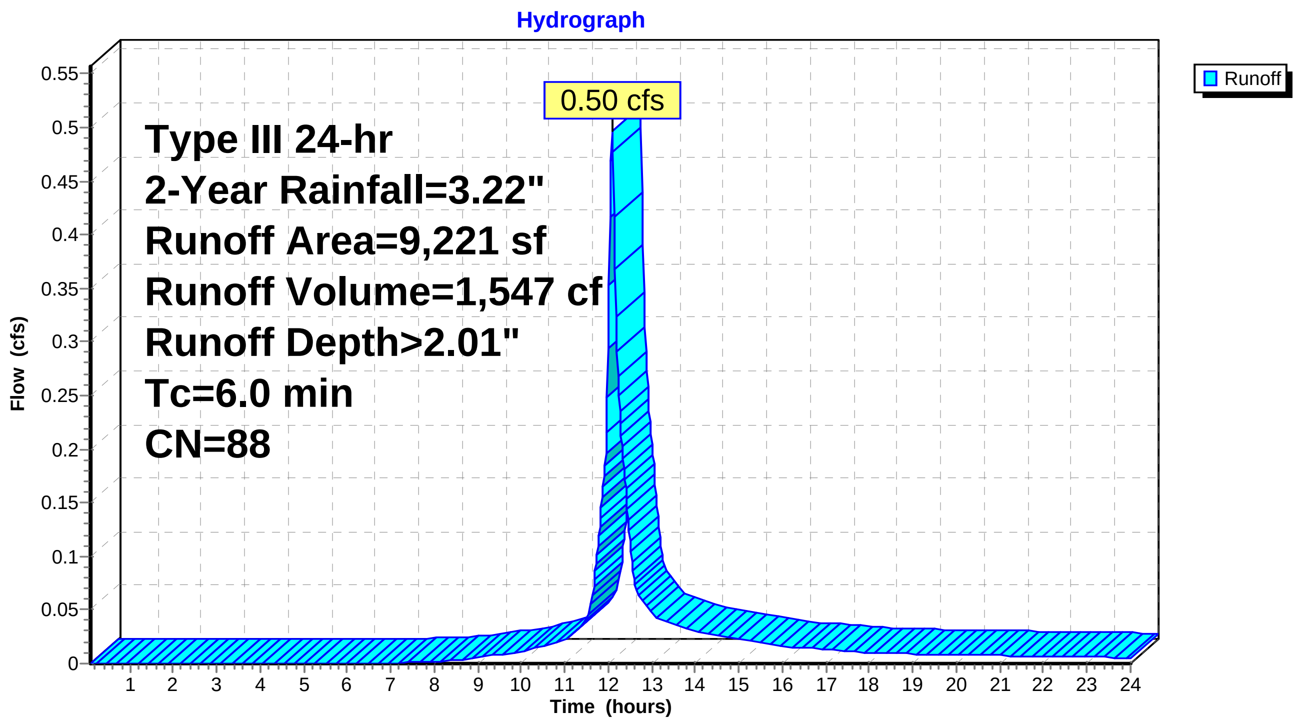
Runoff = 0.50 cfs @ 12.09 hrs, Volume= 1,547 cf, Depth> 2.01"

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 2-Year Rainfall=3.22"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG B
1,177	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
9,221	88	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
6.0					**Direct Entry,**

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

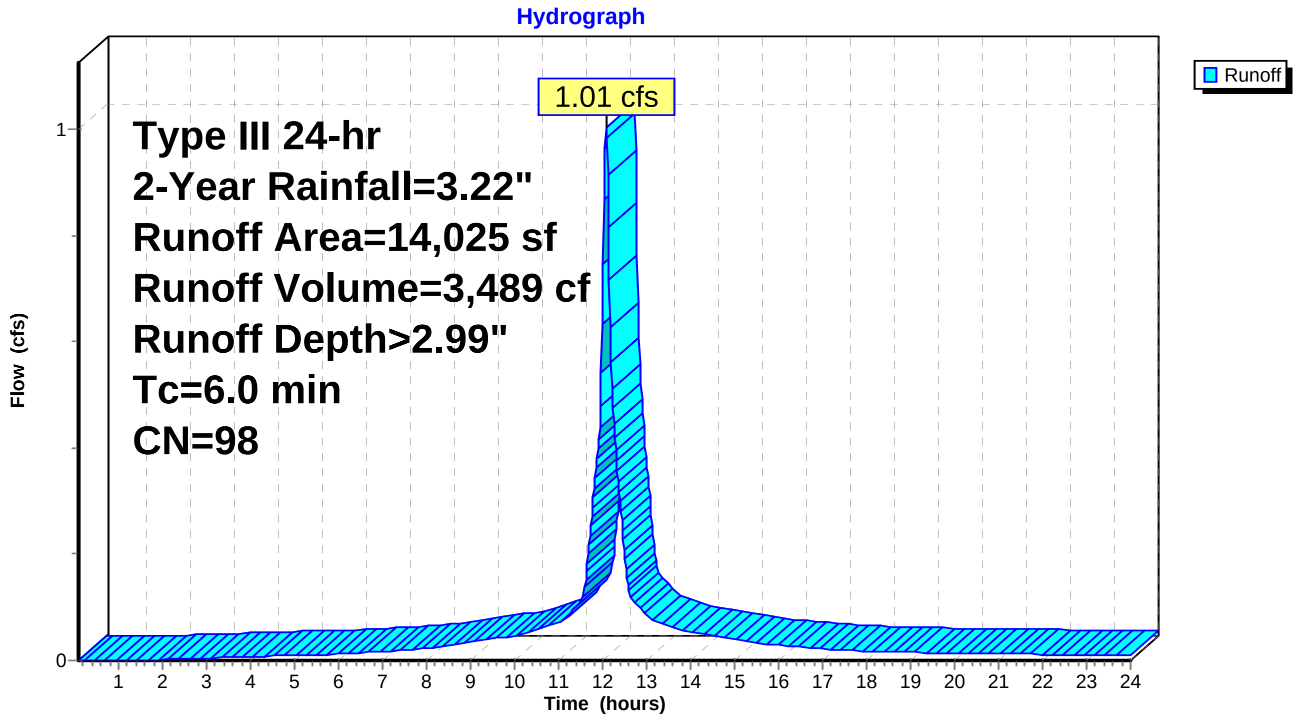
Runoff = 1.01 cfs @ 12.08 hrs, Volume= 3,489 cf, Depth> 2.99"

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=3.22"

Area (sf)	CN	Description
14,025	98	Unconnected roofs, HSG B
14,025		100.00% Impervious Area
14,025		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

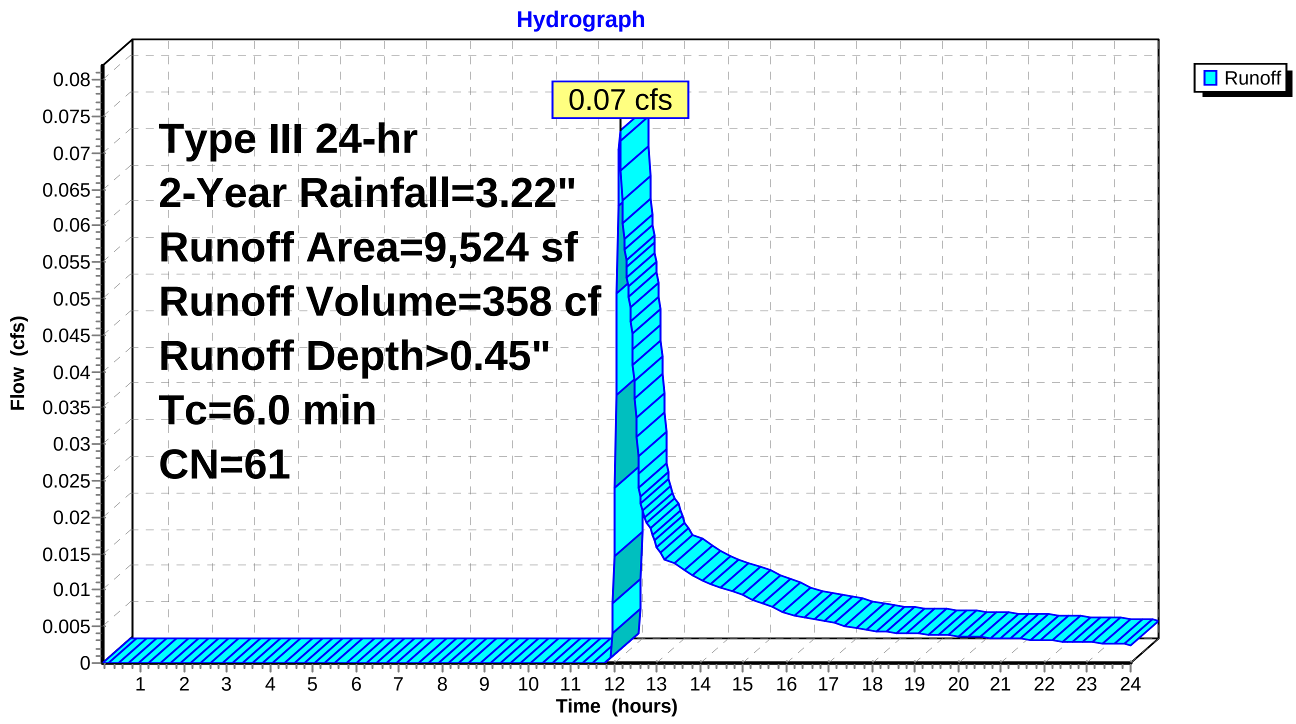
Runoff = 0.07 cfs @ 12.12 hrs, Volume= 358 cf, Depth> 0.45"

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 2-Year Rainfall=3.22"

Area (sf)	CN	Description
6,804	61	>75% Grass cover, Good, HSG B
2,720	60	Woods, Fair, HSG B
9,524	61	Weighted Average
9,524		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Pond 7R: Subsurface Structure

Inflow Area = 14,025 sf,100.00% Impervious, Inflow Depth > 2.99" for 2-Year event
Inflow = 1.01 cfs @ 12.08 hrs, Volume= 3,489 cf
Outflow = 1.01 cfs @ 12.09 hrs, Volume= 2,928 cf, Atten= 0%, Lag= 0.7 min
Discarded = 0.02 cfs @ 7.04 hrs, Volume= 1,170 cf
Primary = 1.00 cfs @ 12.09 hrs, Volume= 1,758 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 199.51' @ 12.09 hrs Surf.Area= 705 sf Storage= 652 cf

Plug-Flow detention time= 108.5 min calculated for 2,928 cf (84% of inflow)
Center-of-Mass det. time= 41.4 min (797.2 - 755.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	197.70'	425 cf	**3.92'W x 180.00'L x 2.04'H Field A** 1,440 cf Overall - 377 cf Embedded = 1,063 cf x 40.0% Voids
#2A	198.03'	292 cf	**ADS N-12 12"** x 18 Inside #1 Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf 18 Chambers in 2 Rows
		717 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	197.70'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	199.50'	**180.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 7.04 hrs HW=197.72' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.83 cfs @ 12.09 hrs HW=199.51' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 0.83 cfs @ 0.37 fps)

Pond 7R: Subsurface Structure - Chamber Wizard Field A

Chamber Model = ADS N-12 12" (ADS N-12® Pipe)
Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf
Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf

14.5" Wide + 6.0" Spacing = 20.5" C-C Row Spacing

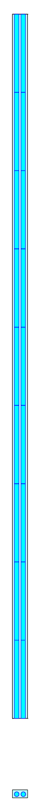
9 Chambers/Row x 20.00' Long = 180.00' Row Length
2 Rows x 14.5" Wide + 6.0" Spacing x 1 + 6.0" Side Stone x 2 = 3.92' Base Width
4.0" Base + 14.5" Chamber Height + 6.0" Cover = 2.04' Field Height

18 Chambers x 16.2 cf = 291.6 cf Chamber Storage
18 Chambers x 20.9 cf = 376.8 cf Displacement

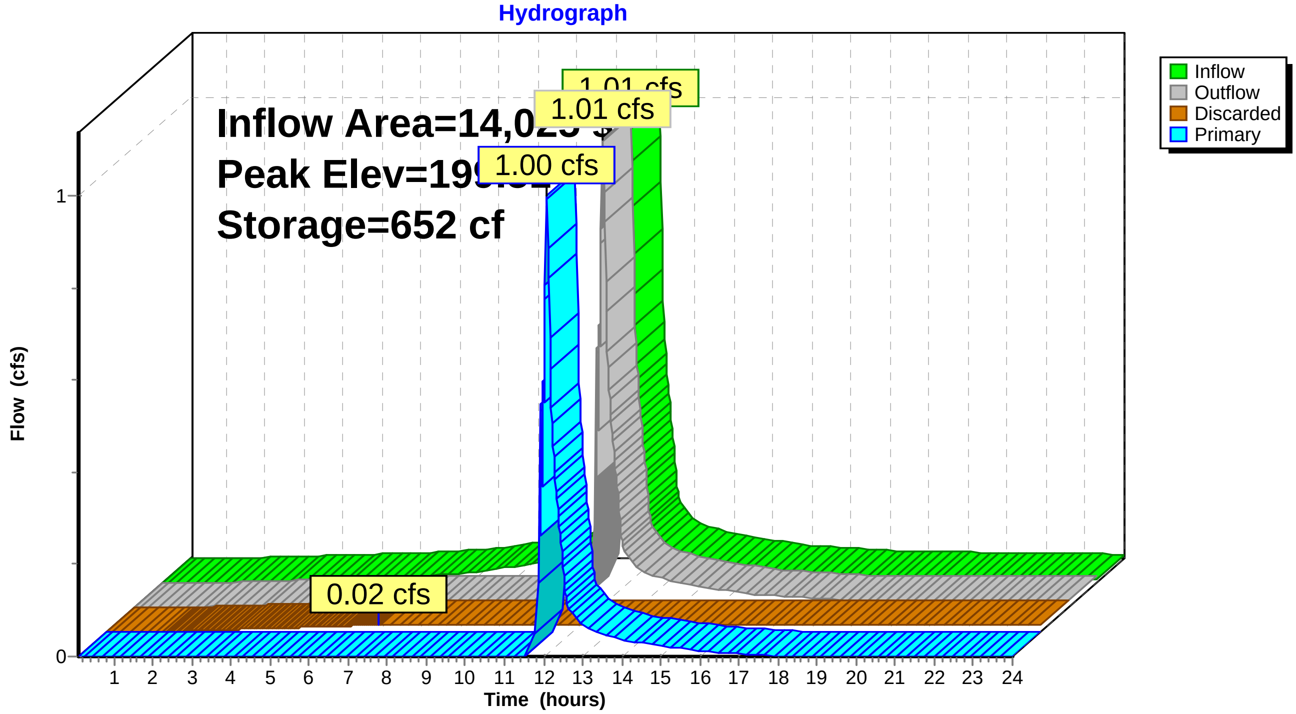
1,440.2 cf Field - 376.8 cf Chambers = 1,063.3 cf Stone x 40.0% Voids = 425.3 cf Stone Storage

Chamber Storage + Stone Storage = 716.9 cf = 0.016 af
Overall Storage Efficiency = 49.8%
Overall System Size = 180.00' x 3.92' x 2.04'

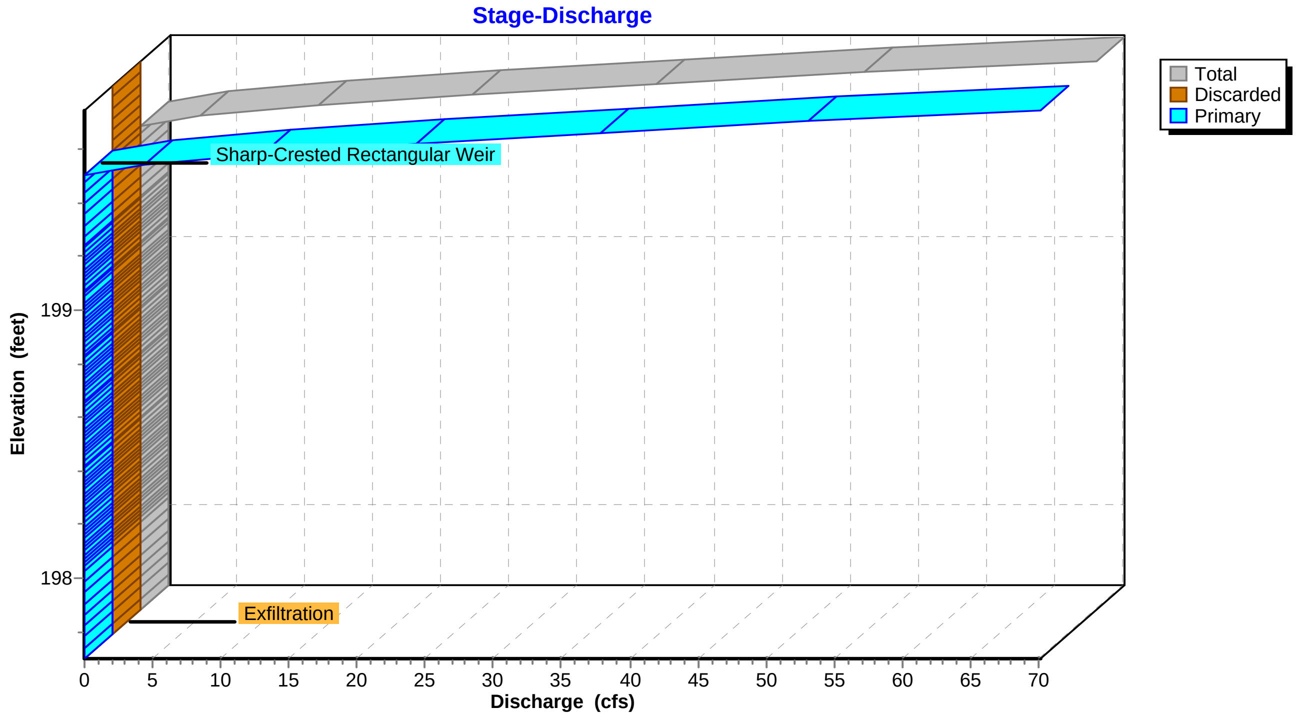
18 Chambers @ $ 0.00 /ea = $ 0.00
53.3 cy Field Excavation @ $ 10.00 /cy = $ 533.39
39.4 cy Stone @ $ 30.00 /cy = $ 1,181.47
Total Cost = $ 1,714.86



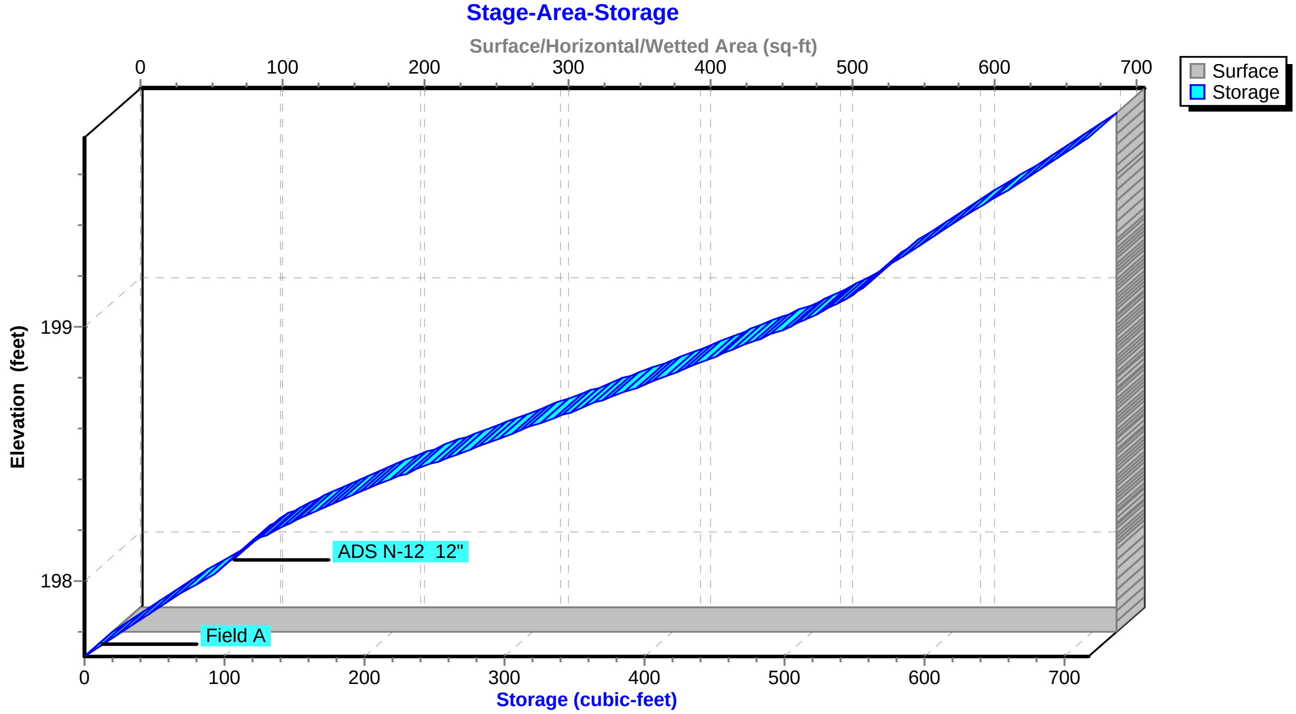
Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure

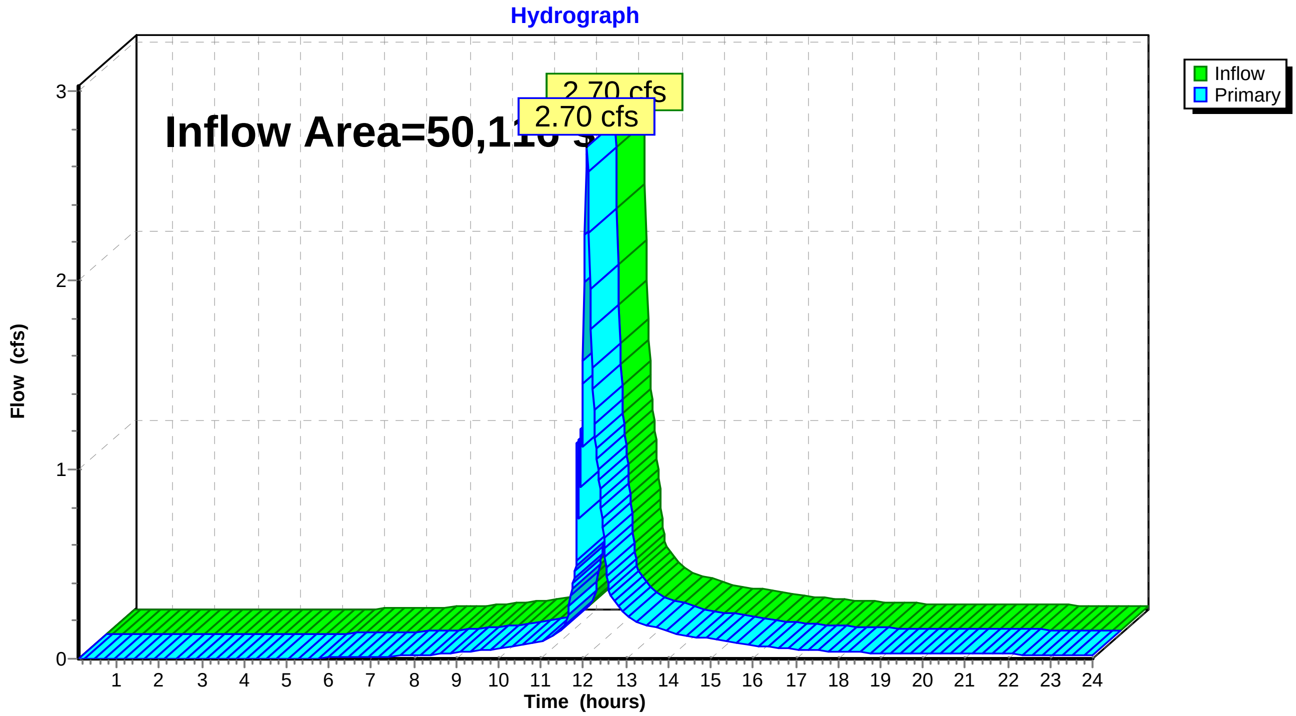


Summary for Link 8L: North West/East Wetland

Inflow Area =	50,116 sf,	43.40% Impervious,	Inflow Depth > 1.77"	for 2-Year event	
Inflow =	2.70 cfs @	12.09 hrs, Volume=	7,382 cf		
Primary =	2.70 cfs @	12.09 hrs, Volume=	7,382 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

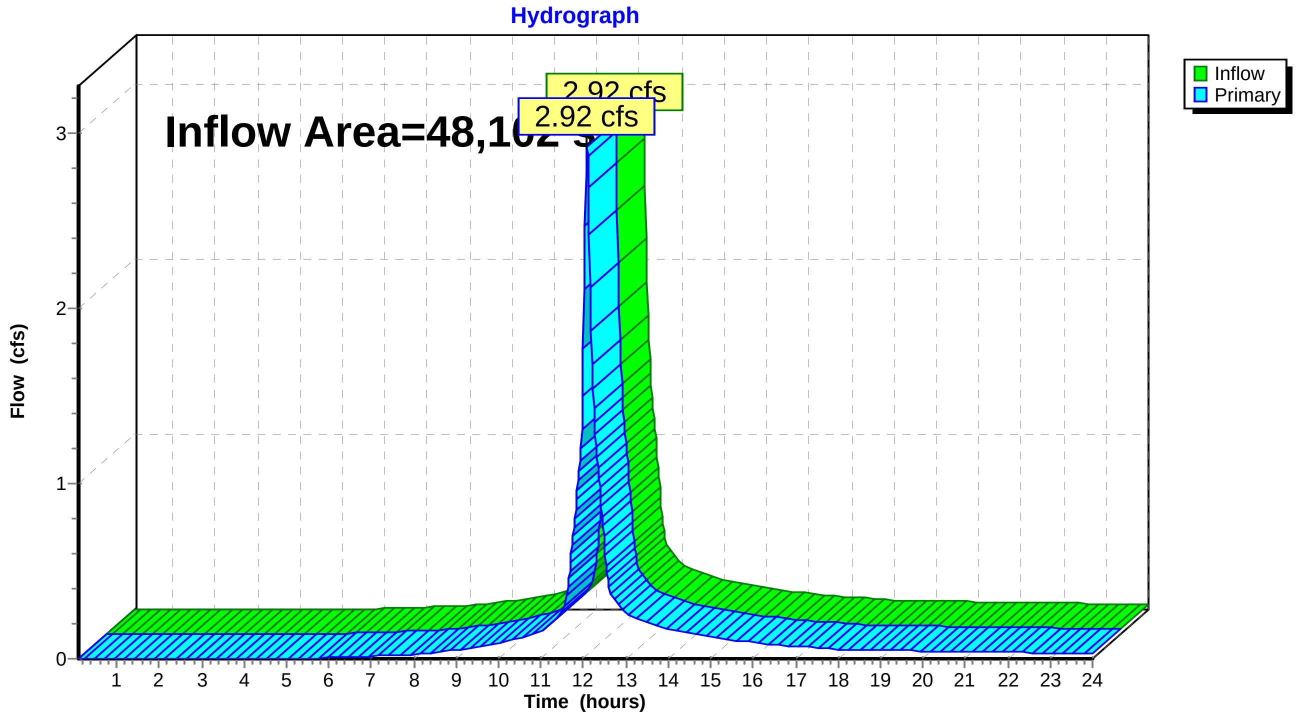


Summary for Link 9L: North West/East Wetland

Inflow Area = 48,102 sf, 45.29% Impervious, Inflow Depth > 2.30" for 2-Year event
Inflow = 2.92 cfs @ 12.09 hrs, Volume= 9,218 cf
Primary = 2.92 cfs @ 12.09 hrs, Volume= 9,218 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 - To Catch Runoff Area=15,970 sf 57.94% Impervious Runoff Depth>3.24"
Tc=6.0 min CN=85 Runoff=1.38 cfs 4,306 cf

Subcatchment 1 PRE: Pre 1 - To Catch Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>3.43"
Tc=6.0 min CN=87 Runoff=1.63 cfs 5,145 cf

Subcatchment 2 POST: Post 2 Runoff Area=17,714 sf 38.51% Impervious Runoff Depth>4.17"
Tc=6.0 min CN=94 Runoff=1.85 cfs 6,150 cf

Subcatchment 2 PRE: Pre 2 Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>3.95"
Tc=6.0 min CN=92 Runoff=3.93 cfs 12,796 cf

Subcatchment 3 Post: Post 3 Runoff Area=8,853 sf 10.22% Impervious Runoff Depth>3.53"
Tc=6.0 min CN=88 Runoff=0.82 cfs 2,606 cf

Subcatchment 3 PRE: Pre 3 Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>3.53"
Tc=6.0 min CN=88 Runoff=0.86 cfs 2,715 cf

Subcatchment 4 POST: Post 4 Runoff Area=14,025 sf 100.00% Impervious Runoff Depth>4.62"
Tc=6.0 min CN=98 Runoff=1.53 cfs 5,400 cf

Subcatchment 5 POST: Post 5 Runoff Area=9,524 sf 0.00% Impervious Runoff Depth>1.28"
Tc=6.0 min CN=61 Runoff=0.30 cfs 1,019 cf

Pond 7R: Subsurface Structure Peak Elev=199.52' Storage=654 cf Inflow=1.53 cfs 5,400 cf
Discarded=0.02 cfs 1,274 cf Primary=1.51 cfs 3,486 cf Outflow=1.53 cfs 4,761 cf

Link 8L: North West/East Wetland Inflow=4.47 cfs 13,262 cf
Primary=4.47 cfs 13,262 cf

Link 9L: North West/East Wetland Inflow=4.79 cfs 15,511 cf
Primary=4.79 cfs 15,511 cf

Total Runoff Area = 132,176 sf Runoff Volume = 40,137 cf Average Runoff Depth = 3.64"
51.40% Pervious = 67,936 sf 48.60% Impervious = 64,240 sf

Summary for Subcatchment 1 POST: Post 1 - To Catch Basin

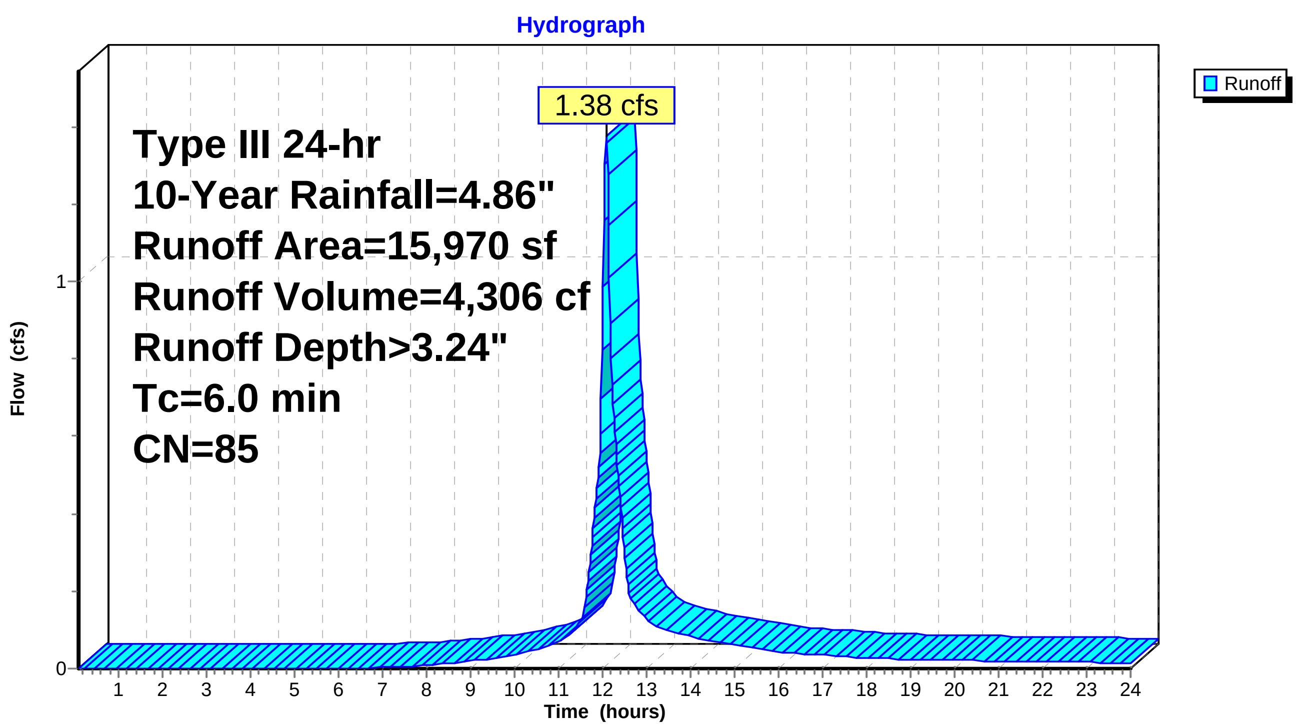
Runoff = 1.38 cfs @ 12.09 hrs, Volume= 4,306 cf, Depth> 3.24"

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=4.86"

Area (sf)	CN	Description
5,953	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
9,253	98	Paved parking, HSG B
15,970	85	Weighted Average
6,717		42.06% Pervious Area
9,253		57.94% Impervious Area

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

Subcatchment 1 POST: Post 1 - To Catch Basin



Summary for Subcatchment 1 PRE: Pre 1 - To Catch Basin

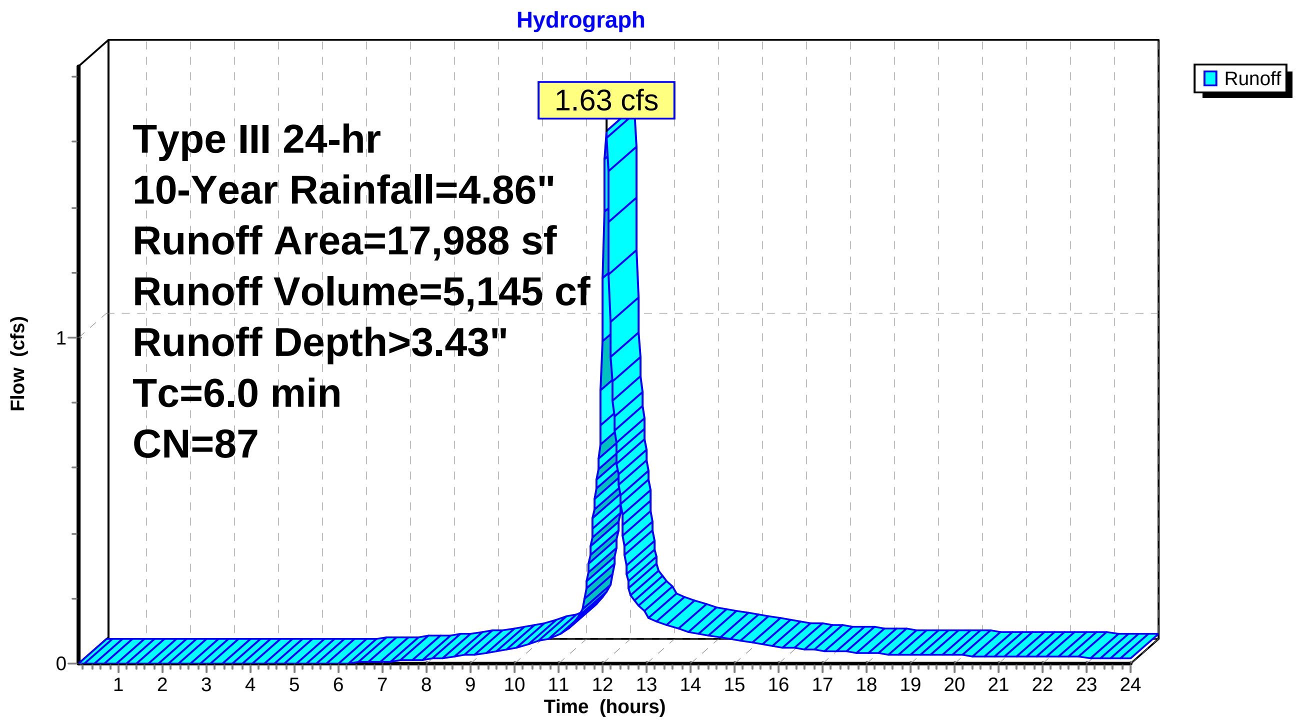
Runoff = 1.63 cfs @ 12.09 hrs, Volume= 5,145 cf, Depth> 3.43"

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=4.86"

Area (sf)	CN	Description
5,774	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
11,450	98	Paved parking, HSG B
17,988	87	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
6.0					**Direct Entry,**

Subcatchment 1 PRE: Pre 1 - To Catch Basin



Summary for Subcatchment 2 POST: Post 2

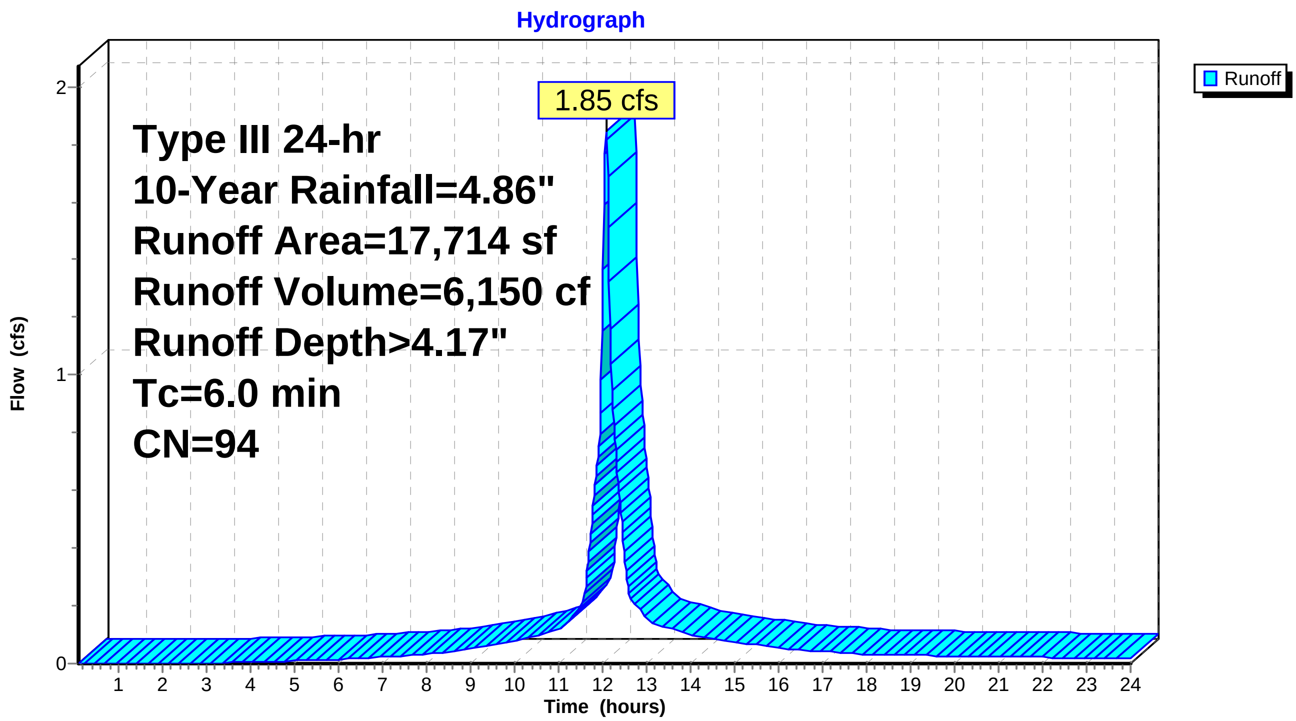
Runoff = 1.85 cfs @ 12.08 hrs, Volume= 6,150 cf, Depth> 4.17"

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 10-Year Rainfall=4.86"

Area (sf)	CN	Description
1,563	60	Woods, Fair, HSG B
6,822	98	Paved parking, HSG B
9,329	96	Gravel surface, HSG B
17,714	94	Weighted Average
10,892		61.49% Pervious Area
6,822		38.51% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

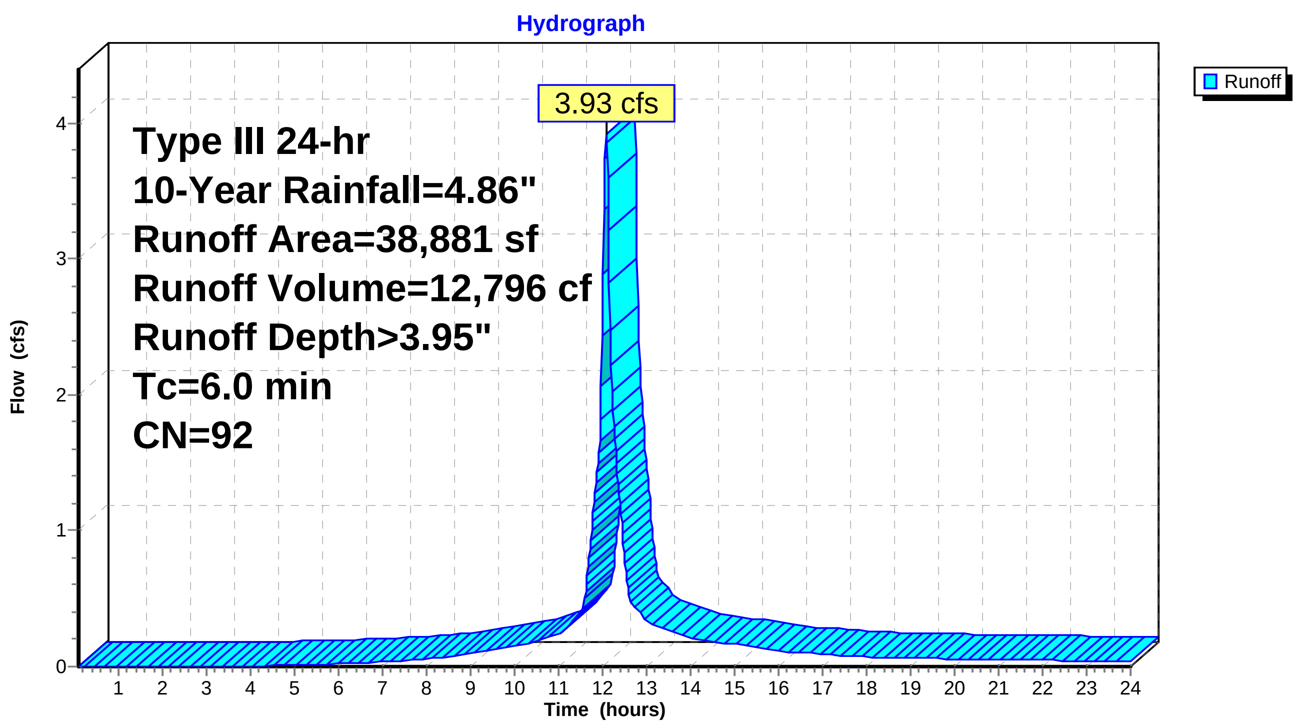
Runoff = 3.93 cfs @ 12.08 hrs, Volume= 12,796 cf, Depth> 3.95"

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=4.86"

Area (sf)	CN	Description
4,958	60	Woods, Fair, HSG B
6,631	98	Roofs, HSG B
13,977	98	Paved parking, HSG B
13,315	96	Gravel surface, HSG B
38,881	92	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
6.0					**Direct Entry,**

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

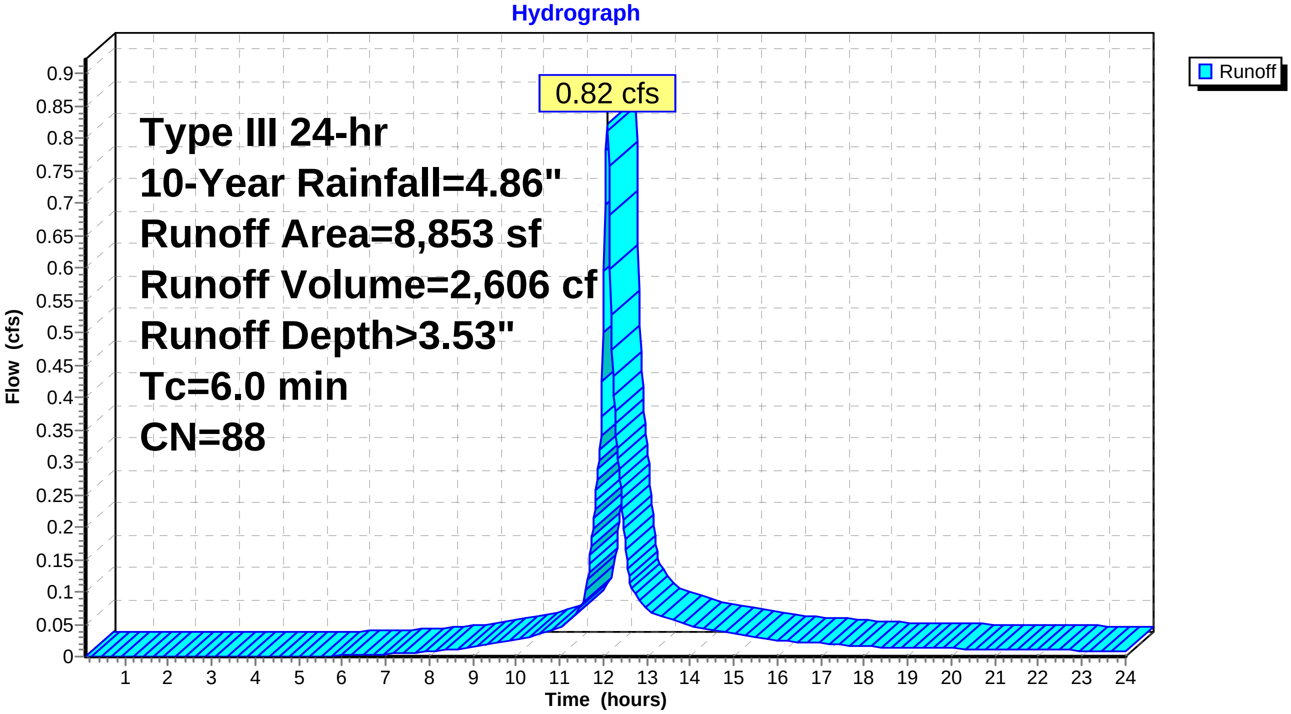
Runoff = 0.82 cfs @ 12.09 hrs, Volume= 2,606 cf, Depth> 3.53"

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=4.86"

Area (sf)	CN	Description
5,832	96	Gravel surface, HSG B
905	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
8,853	88	Weighted Average
7,948		89.78% Pervious Area
905		10.22% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

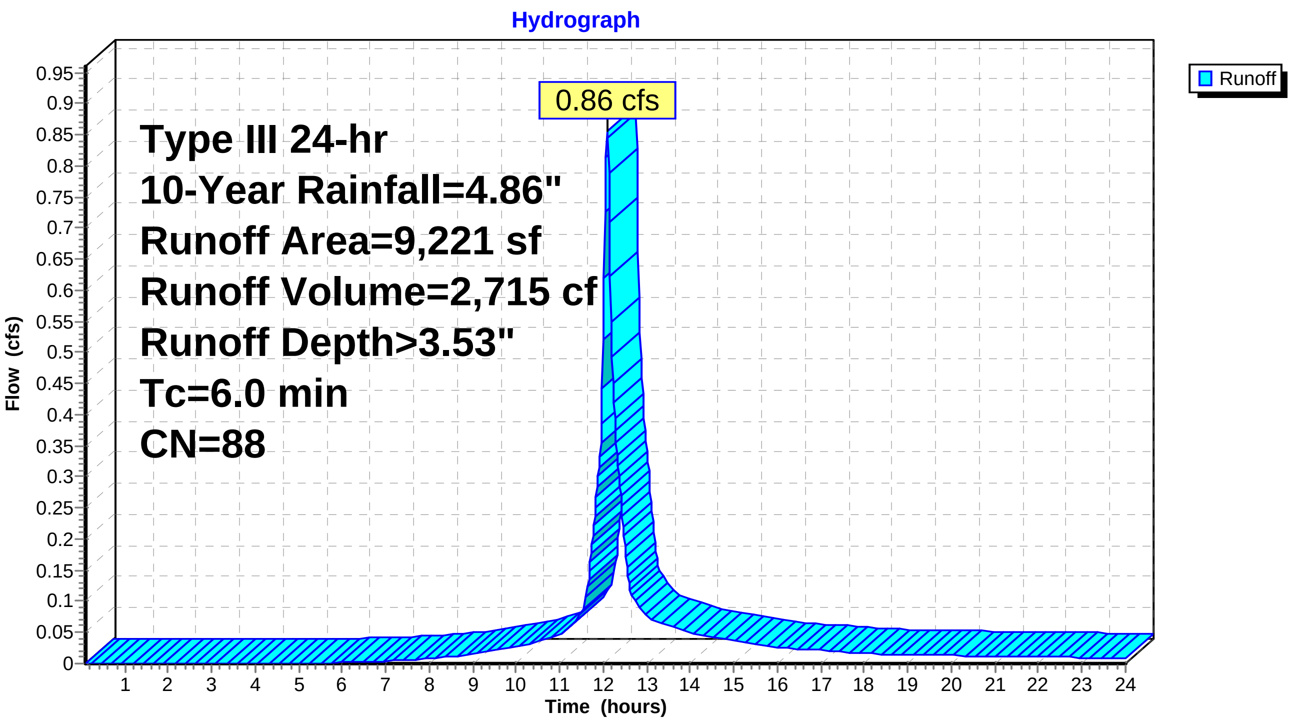
Runoff = 0.86 cfs @ 12.09 hrs, Volume= 2,715 cf, Depth> 3.53"

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=4.86"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG B
1,177	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
9,221	88	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
6.0					**Direct Entry,**

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

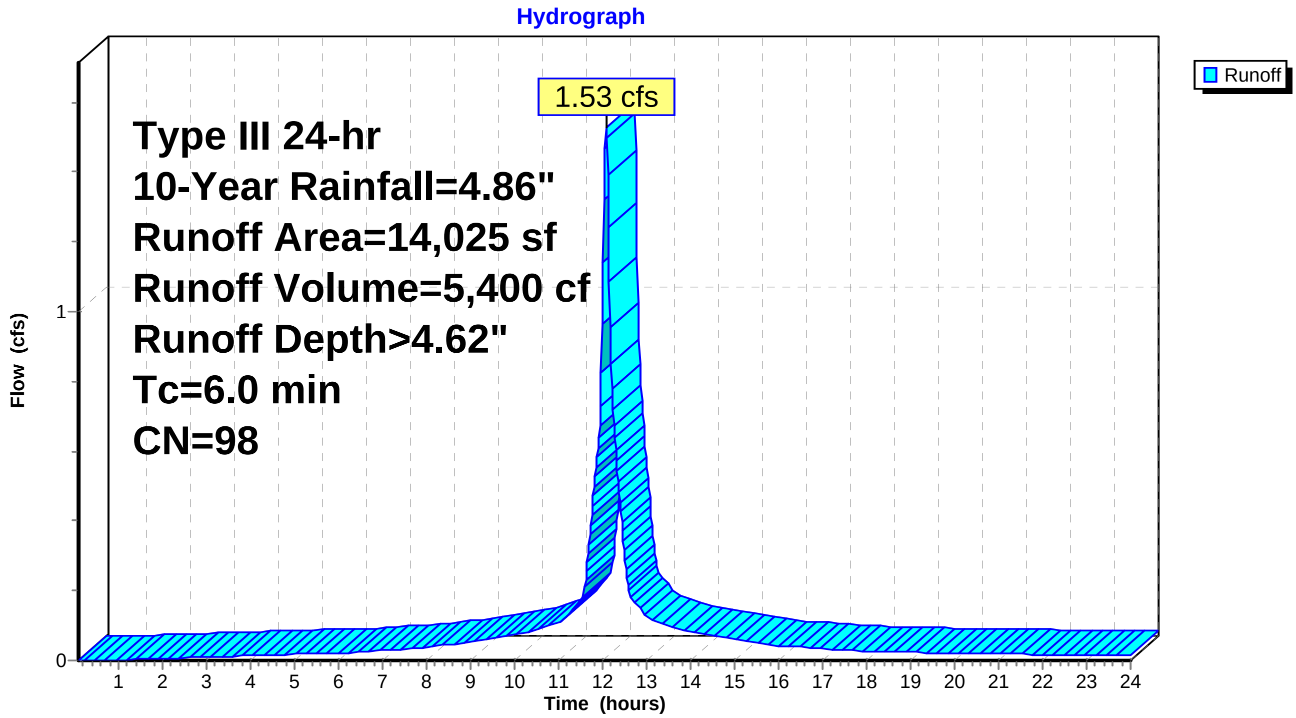
Runoff = 1.53 cfs @ 12.08 hrs, Volume= 5,400 cf, Depth> 4.62"

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=4.86"

Area (sf)	CN	Description
14,025	98	Unconnected roofs, HSG B
14,025		100.00% Impervious Area
14,025		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

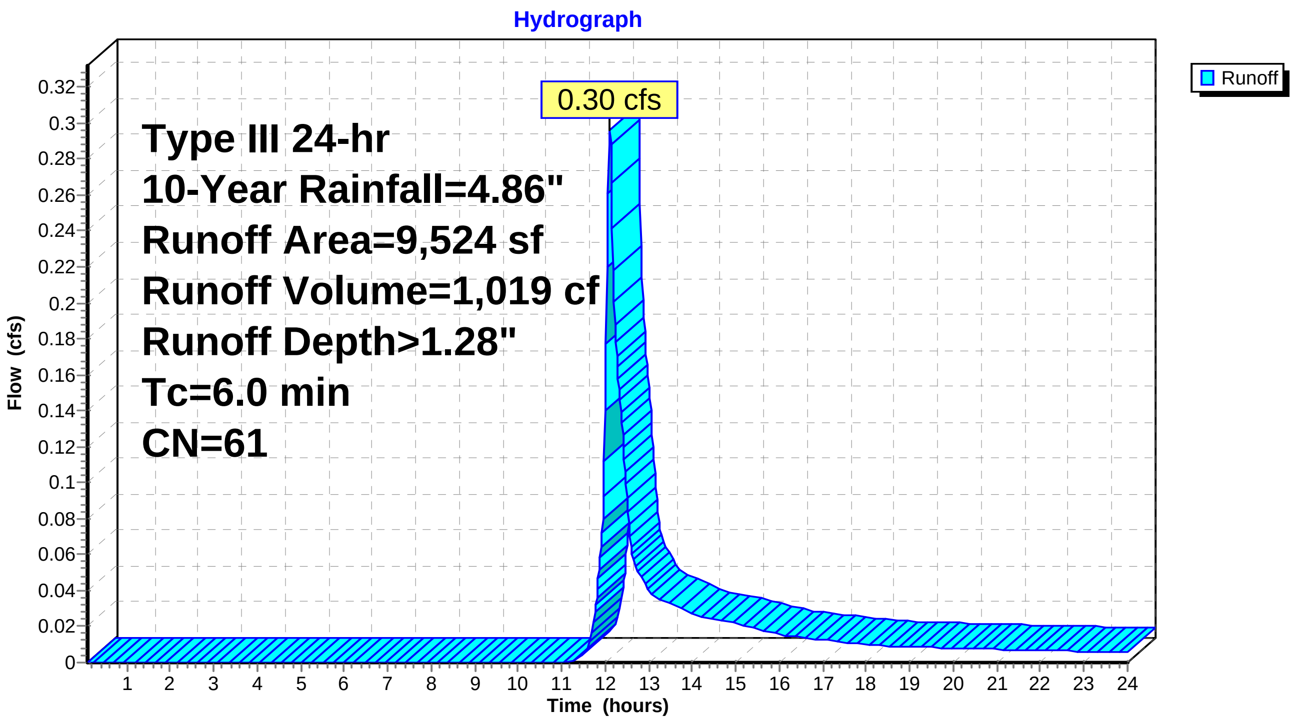
Runoff = 0.30 cfs @ 12.10 hrs, Volume= 1,019 cf, Depth> 1.28"

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 10-Year Rainfall=4.86"

Area (sf)	CN	Description
6,804	61	>75% Grass cover, Good, HSG B
2,720	60	Woods, Fair, HSG B
9,524	61	Weighted Average
9,524		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Pond 7R: Subsurface Structure

Inflow Area = 14,025 sf,100.00% Impervious, Inflow Depth > 4.62" for 10-Year event
Inflow = 1.53 cfs @ 12.08 hrs, Volume= 5,400 cf
Outflow = 1.53 cfs @ 12.08 hrs, Volume= 4,761 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.02 cfs @ 4.84 hrs, Volume= 1,274 cf
Primary = 1.51 cfs @ 12.08 hrs, Volume= 3,486 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 199.52' @ 12.08 hrs Surf.Area= 705 sf Storage= 654 cf

Plug-Flow detention time= 82.3 min calculated for 4,761 cf (88% of inflow)
Center-of-Mass det. time= 26.6 min (774.6 - 748.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	197.70'	425 cf	**3.92'W x 180.00'L x 2.04'H Field A** 1,440 cf Overall - 377 cf Embedded = 1,063 cf x 40.0% Voids
#2A	198.03'	292 cf	**ADS N-12 12"** x 18 Inside #1 Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf 18 Chambers in 2 Rows
		717 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	197.70'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	199.50'	**180.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 4.84 hrs HW=197.72' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=1.48 cfs @ 12.08 hrs HW=199.52' (Free Discharge)
↑—**2=Sharp-Crested Rectangular Weir** (Weir Controls 1.48 cfs @ 0.44 fps)

Pond 7R: Subsurface Structure - Chamber Wizard Field A

Chamber Model = ADS N-12 12" (ADS N-12® Pipe)
Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf
Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf

14.5" Wide + 6.0" Spacing = 20.5" C-C Row Spacing

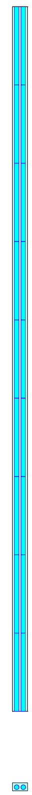
9 Chambers/Row x 20.00' Long = 180.00' Row Length
2 Rows x 14.5" Wide + 6.0" Spacing x 1 + 6.0" Side Stone x 2 = 3.92' Base Width
4.0" Base + 14.5" Chamber Height + 6.0" Cover = 2.04' Field Height

18 Chambers x 16.2 cf = 291.6 cf Chamber Storage
18 Chambers x 20.9 cf = 376.8 cf Displacement

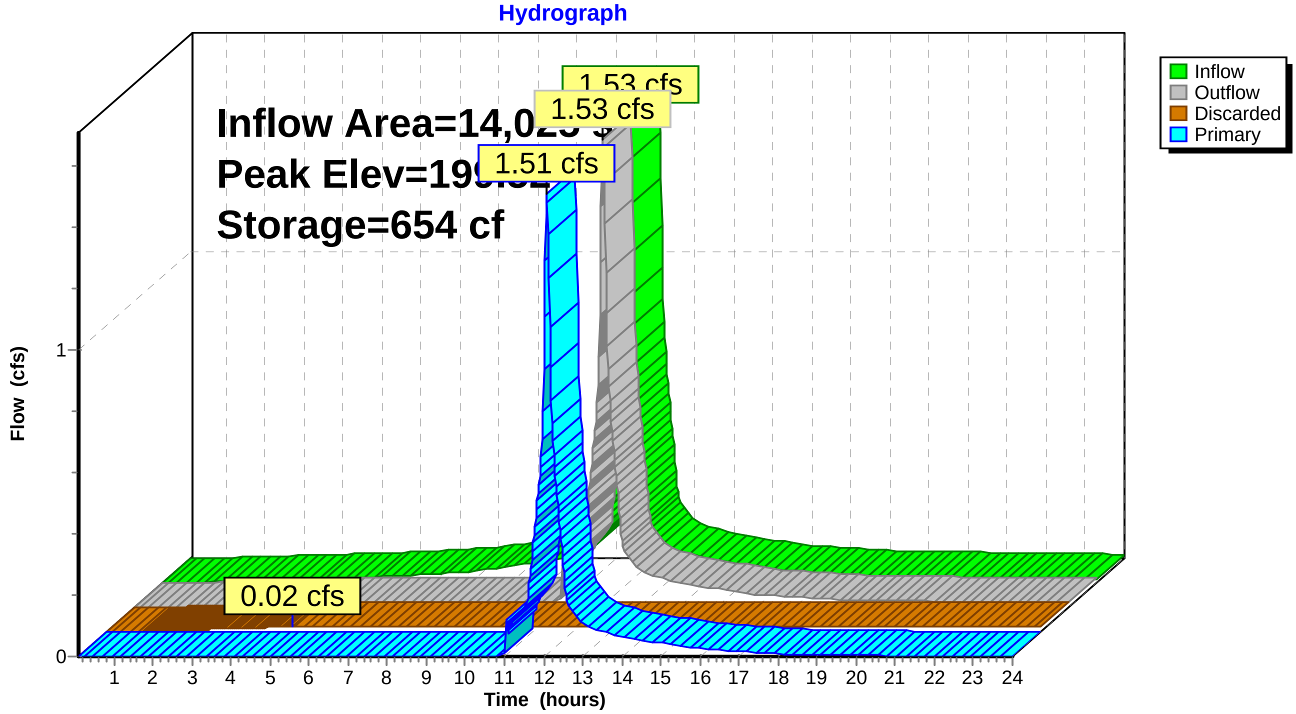
1,440.2 cf Field - 376.8 cf Chambers = 1,063.3 cf Stone x 40.0% Voids = 425.3 cf Stone Storage

Chamber Storage + Stone Storage = 716.9 cf = 0.016 af
Overall Storage Efficiency = 49.8%
Overall System Size = 180.00' x 3.92' x 2.04'

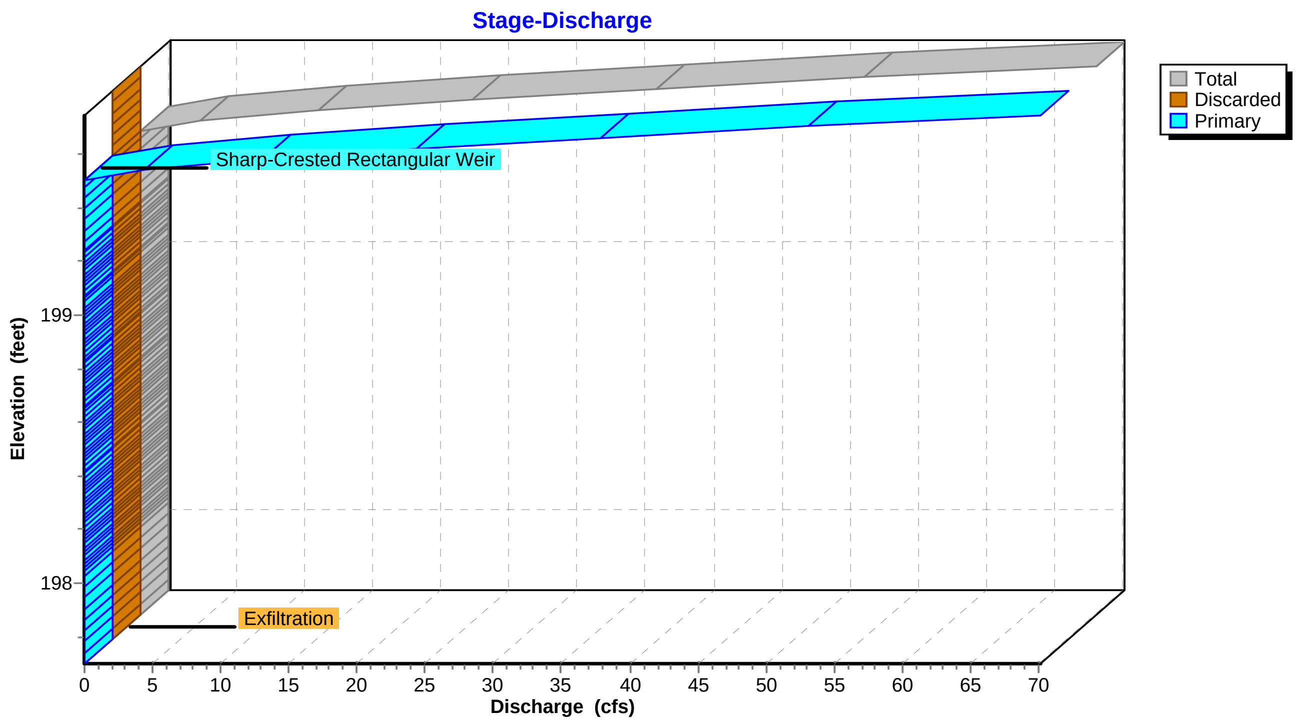
18 Chambers @ $ 0.00 /ea = $ 0.00
53.3 cy Field Excavation @ $ 10.00 /cy = $ 533.39
39.4 cy Stone @ $ 30.00 /cy = $ 1,181.47
Total Cost = $ 1,714.86



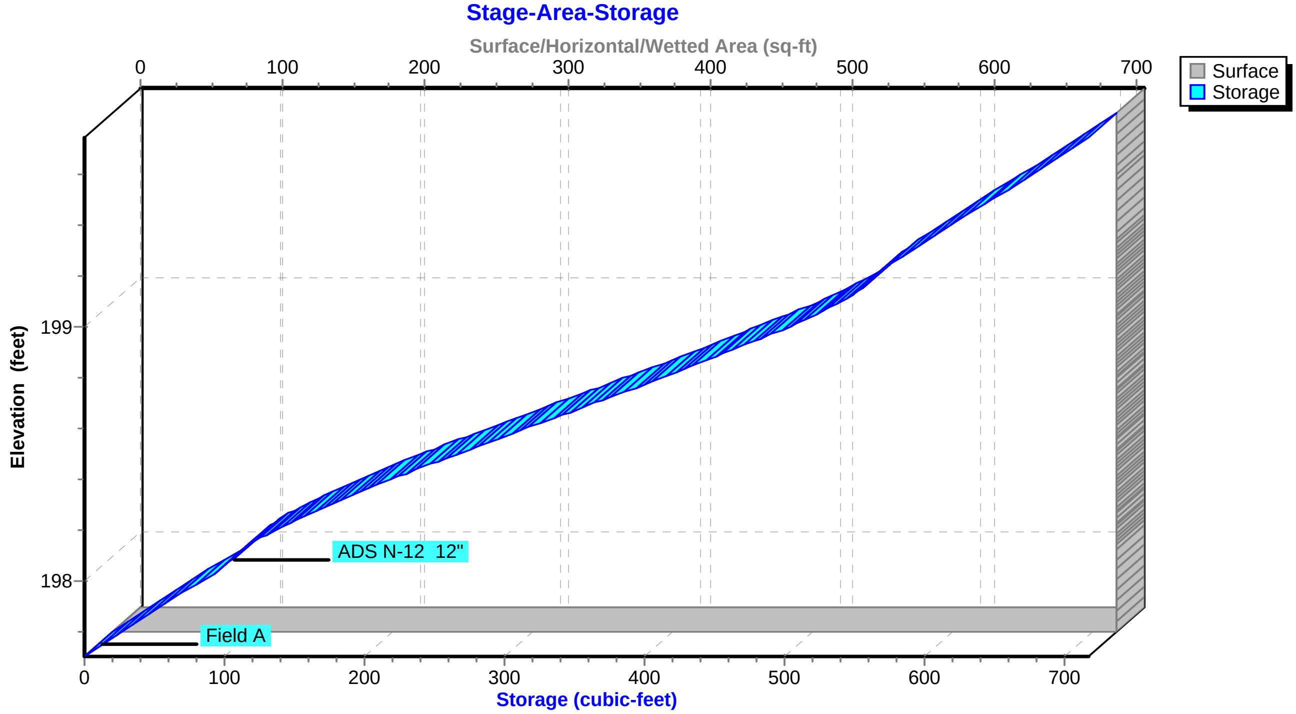
Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure

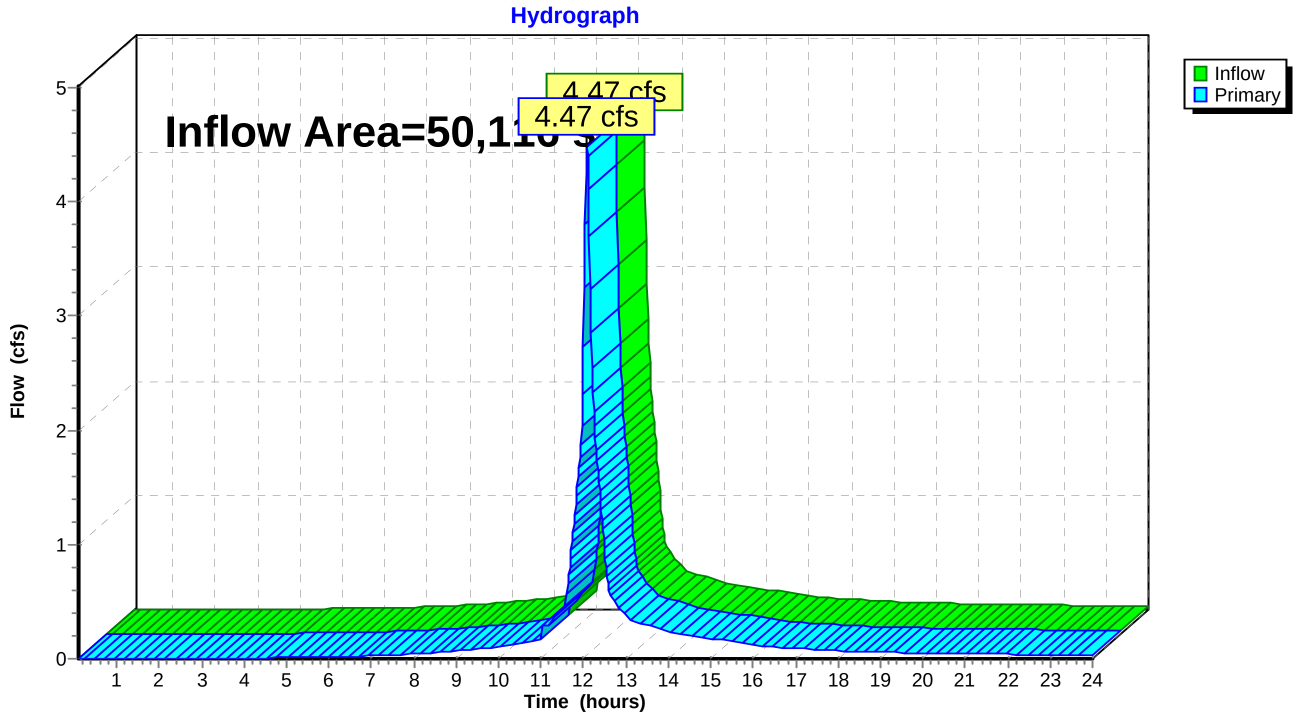


Summary for Link 8L: North West/East Wetland

Inflow Area = 50,116 sf, 43.40% Impervious, Inflow Depth > 3.18" for 10-Year event
Inflow = 4.47 cfs @ 12.09 hrs, Volume= 13,262 cf
Primary = 4.47 cfs @ 12.09 hrs, Volume= 13,262 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

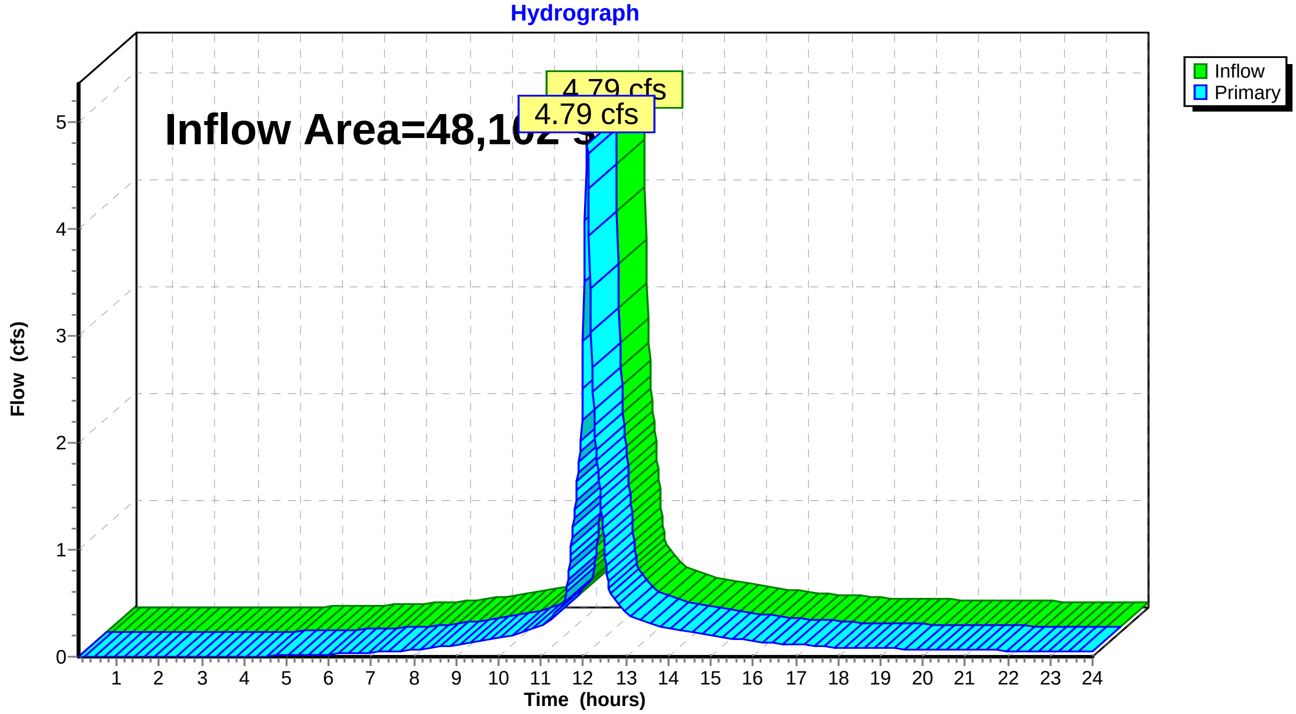


Summary for Link 9L: North West/East Wetland

Inflow Area =	48,102 sf,	45.29% Impervious,	Inflow Depth > 3.87"	for 10-Year event
Inflow =	4.79 cfs @	12.08 hrs, Volume=	15,511 cf	
Primary =	4.79 cfs @	12.08 hrs, Volume=	15,511 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 - To Catch Runoff Area=15,970 sf 57.94% Impervious Runoff Depth>4.44"
Tc=6.0 min CN=85 Runoff=1.87 cfs 5,909 cf

Subcatchment 1 PRE: Pre 1 - To Catch Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>4.66"
Tc=6.0 min CN=87 Runoff=2.19 cfs 6,980 cf

Subcatchment 2 POST: Post 2 Runoff Area=17,714 sf 38.51% Impervious Runoff Depth>5.44"
Tc=6.0 min CN=94 Runoff=2.38 cfs 8,032 cf

Subcatchment 2 PRE: Pre 2 Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>5.21"
Tc=6.0 min CN=92 Runoff=5.10 cfs 16,890 cf

Subcatchment 3 Post: Post 3 Runoff Area=8,853 sf 10.22% Impervious Runoff Depth>4.77"
Tc=6.0 min CN=88 Runoff=1.09 cfs 3,516 cf

Subcatchment 3 PRE: Pre 3 Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>4.77"
Tc=6.0 min CN=88 Runoff=1.14 cfs 3,662 cf

Subcatchment 4 POST: Post 4 Runoff Area=14,025 sf 100.00% Impervious Runoff Depth>5.91"
Tc=6.0 min CN=98 Runoff=1.94 cfs 6,904 cf

Subcatchment 5 POST: Post 5 Runoff Area=9,524 sf 0.00% Impervious Runoff Depth>2.10"
Tc=6.0 min CN=61 Runoff=0.52 cfs 1,670 cf

Pond 7R: Subsurface Structure Peak Elev=199.52' Storage=655 cf Inflow=1.94 cfs 6,904 cf
Discarded=0.02 cfs 1,320 cf Primary=1.92 cfs 4,935 cf Outflow=1.94 cfs 6,256 cf

Link 8L: North West/East Wetland Inflow=5.91 cfs 18,153 cf
Primary=5.91 cfs 18,153 cf

Link 9L: North West/East Wetland Inflow=6.24 cfs 20,552 cf
Primary=6.24 cfs 20,552 cf

Total Runoff Area = 132,176 sf Runoff Volume = 53,563 cf Average Runoff Depth = 4.86"
51.40% Pervious = 67,936 sf 48.60% Impervious = 64,240 sf

Summary for Subcatchment 1 POST: Post 1 - To Catch Basin

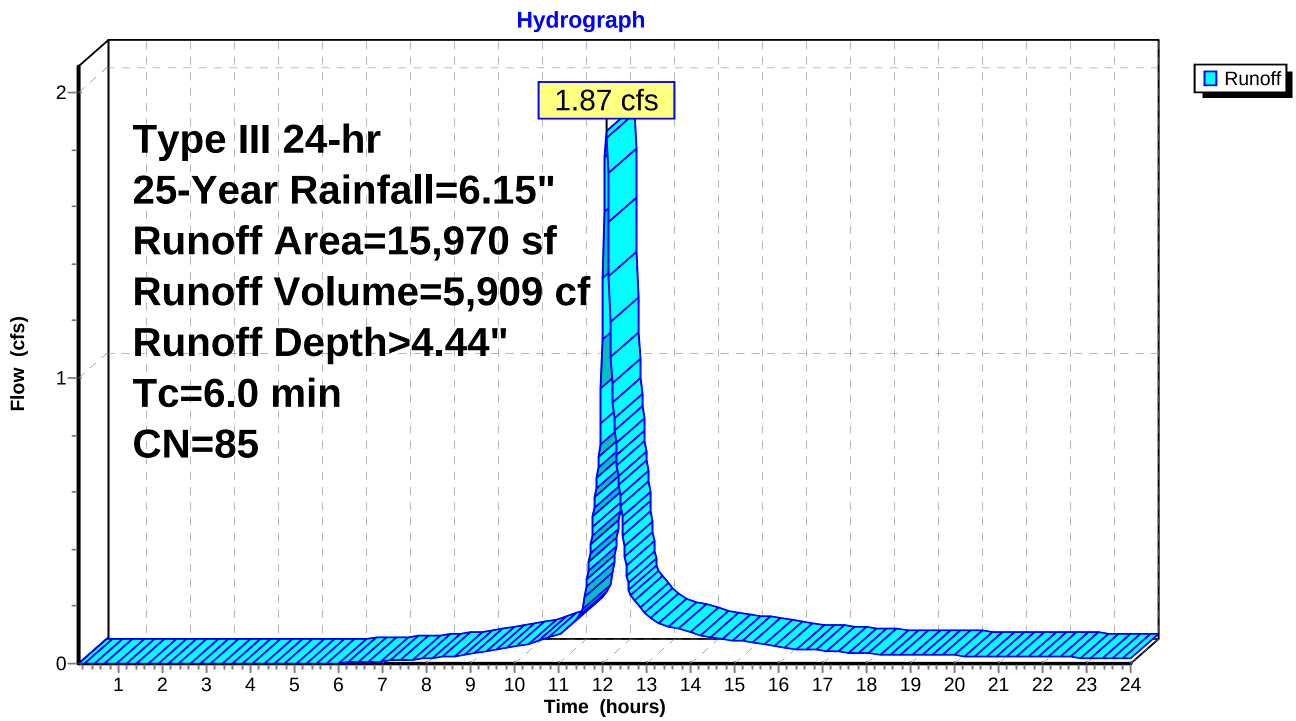
Runoff = 1.87 cfs @ 12.09 hrs, Volume= 5,909 cf, Depth> 4.44"

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 25-Year Rainfall=6.15"

Area (sf)	CN	Description
5,953	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
9,253	98	Paved parking, HSG B
15,970	85	Weighted Average
6,717		42.06% Pervious Area
9,253		57.94% Impervious Area

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

Subcatchment 1 POST: Post 1 - To Catch Basin



Summary for Subcatchment 1 PRE: Pre 1 - To Catch Basin

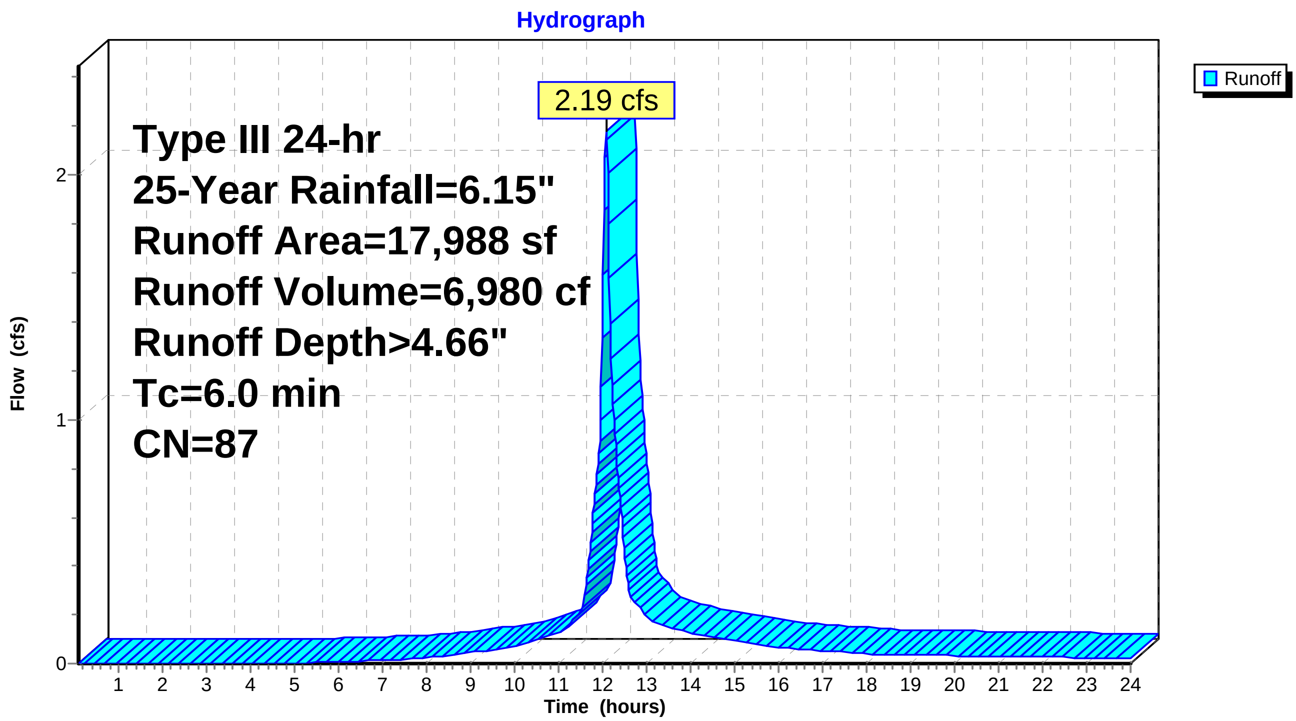
Runoff = 2.19 cfs @ 12.09 hrs, Volume= 6,980 cf, Depth> 4.66"

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=6.15"

Area (sf)	CN	Description
5,774	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
11,450	98	Paved parking, HSG B
17,988	87	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
6.0					**Direct Entry,**

Subcatchment 1 PRE: Pre 1 - To Catch Basin



Summary for Subcatchment 2 POST: Post 2

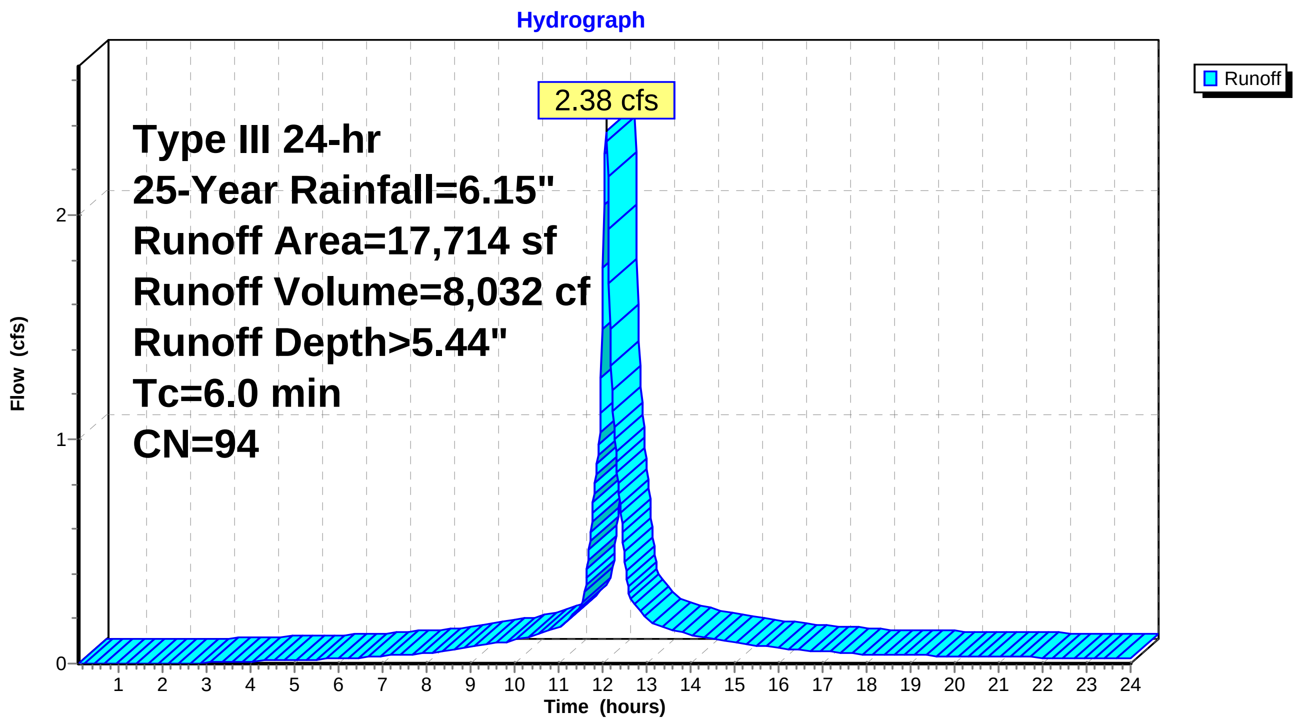
Runoff = 2.38 cfs @ 12.08 hrs, Volume= 8,032 cf, Depth> 5.44"

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 25-Year Rainfall=6.15"

Area (sf)	CN	Description
1,563	60	Woods, Fair, HSG B
6,822	98	Paved parking, HSG B
9,329	96	Gravel surface, HSG B
17,714	94	Weighted Average
10,892		61.49% Pervious Area
6,822		38.51% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

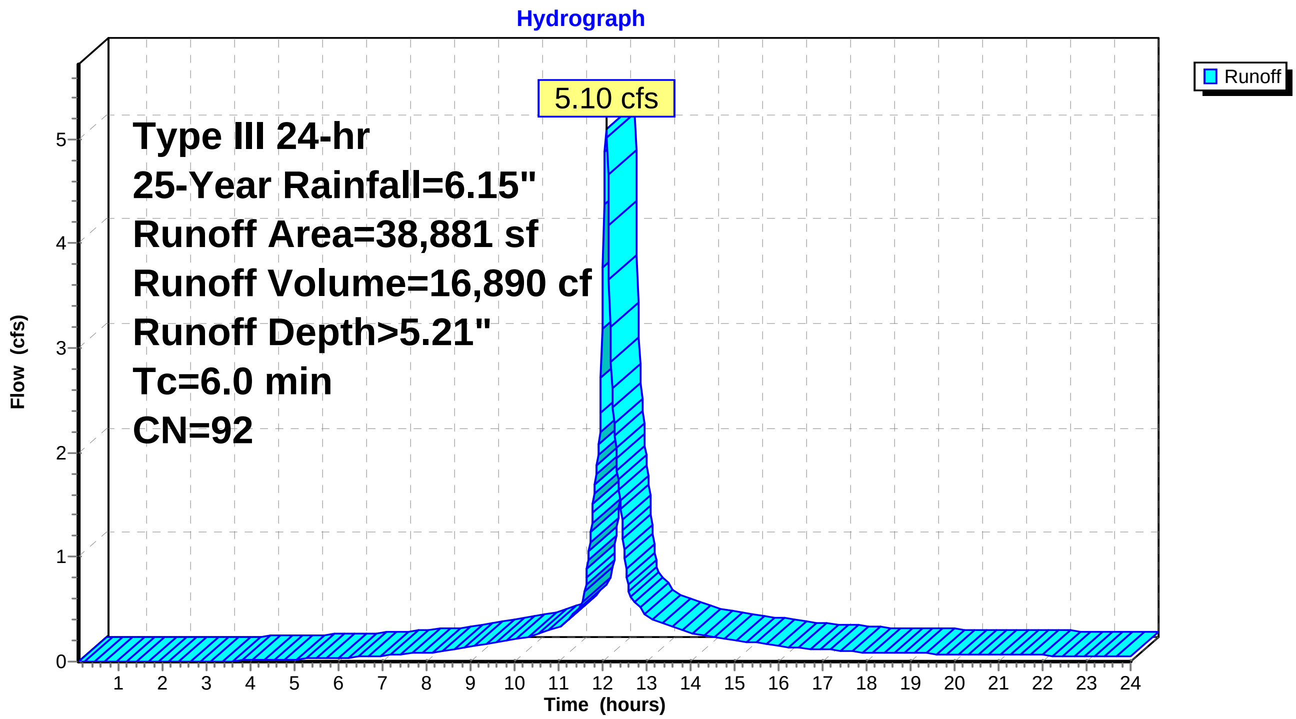
Runoff = 5.10 cfs @ 12.08 hrs, Volume= 16,890 cf, Depth> 5.21"

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=6.15"

Area (sf)	CN	Description
4,958	60	Woods, Fair, HSG B
6,631	98	Roofs, HSG B
13,977	98	Paved parking, HSG B
13,315	96	Gravel surface, HSG B
38,881	92	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
6.0					**Direct Entry,**

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

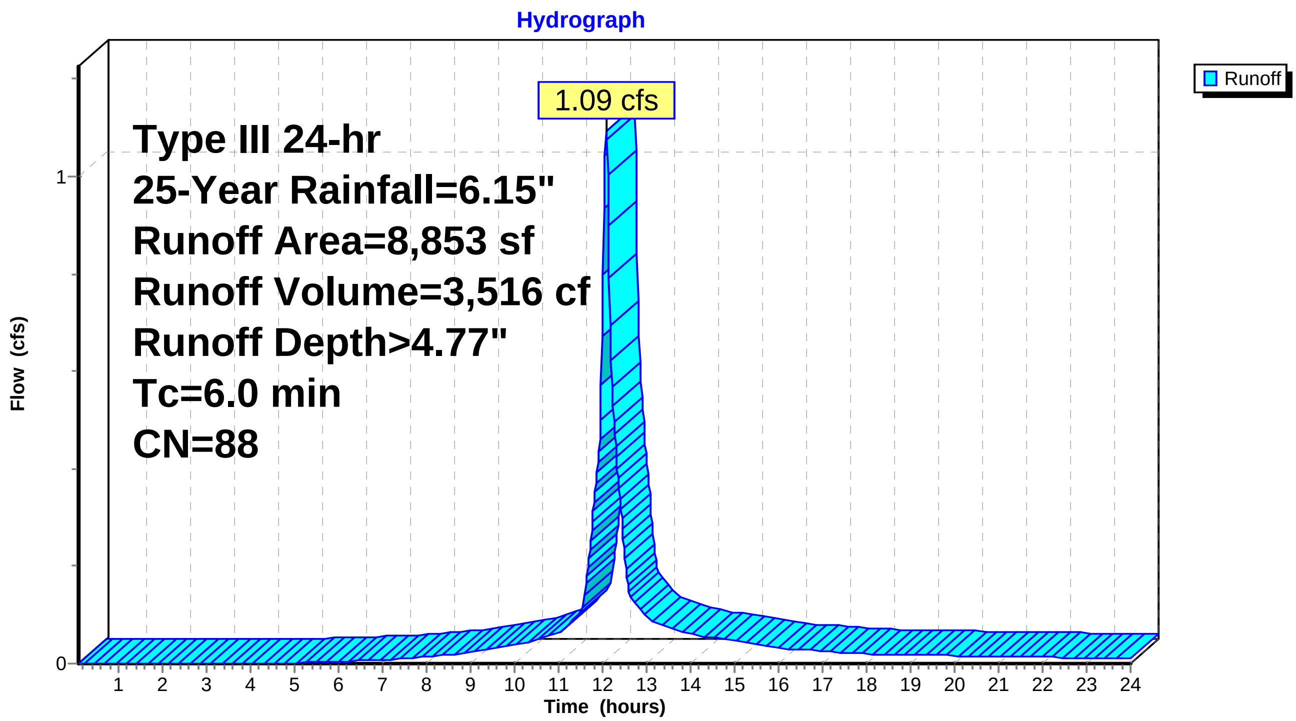
Runoff = 1.09 cfs @ 12.09 hrs, Volume= 3,516 cf, Depth> 4.77"

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=6.15"

Area (sf)	CN	Description
5,832	96	Gravel surface, HSG B
905	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
8,853	88	Weighted Average
7,948		89.78% Pervious Area
905		10.22% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

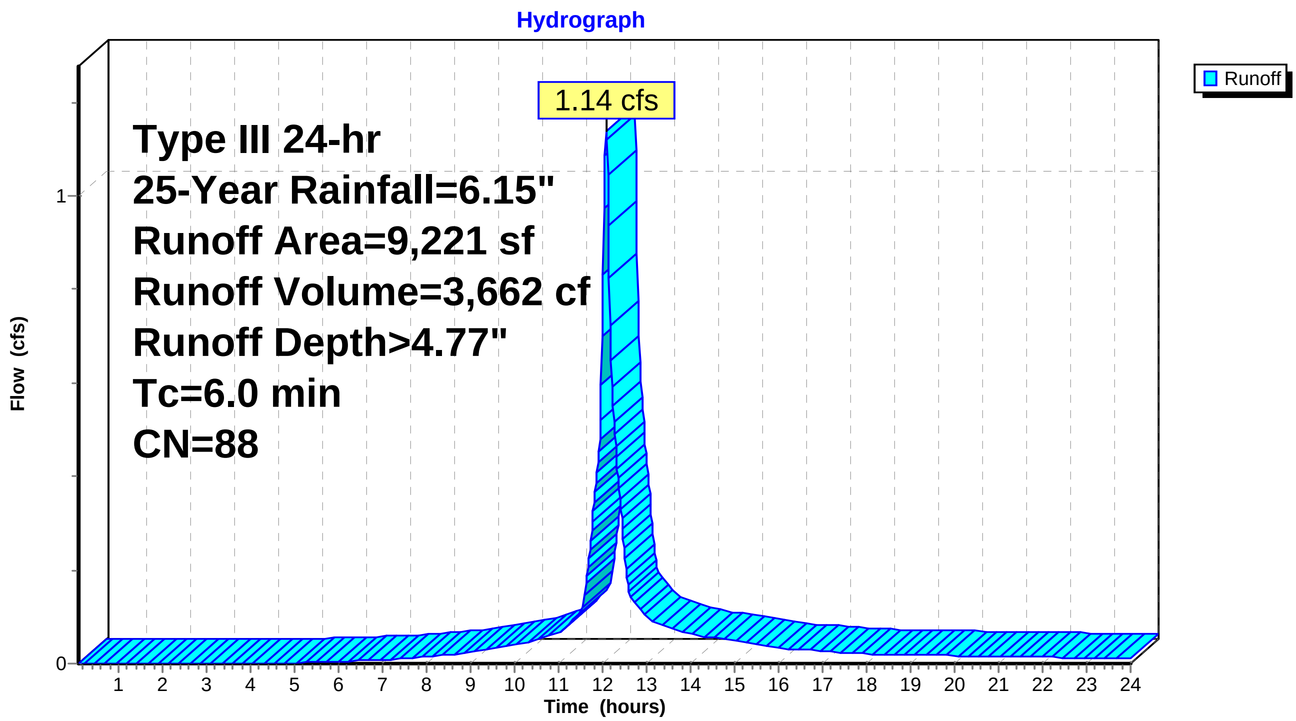
Runoff = 1.14 cfs @ 12.09 hrs, Volume= 3,662 cf, Depth> 4.77"

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=6.15"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG B
1,177	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
9,221	88	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
6.0					**Direct Entry,**

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

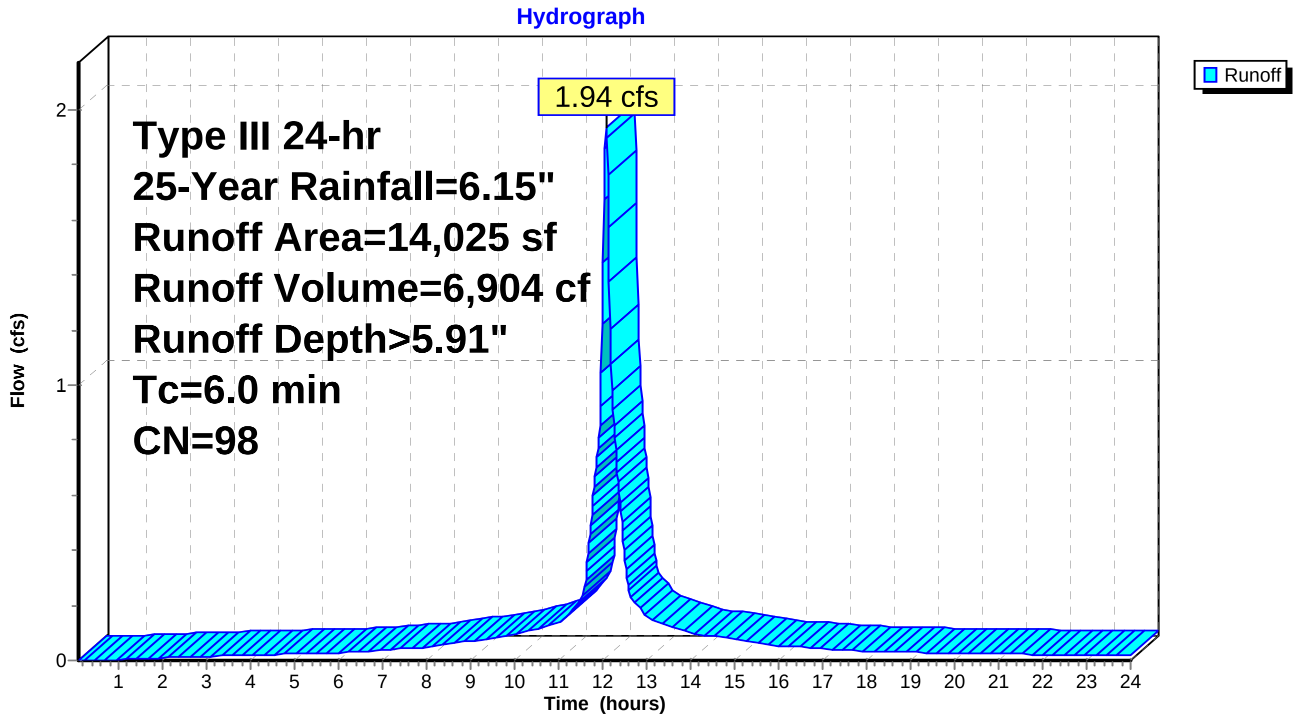
Runoff = 1.94 cfs @ 12.08 hrs, Volume= 6,904 cf, Depth> 5.91"

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=6.15"

Area (sf)	CN	Description
14,025	98	Unconnected roofs, HSG B
14,025		100.00% Impervious Area
14,025		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

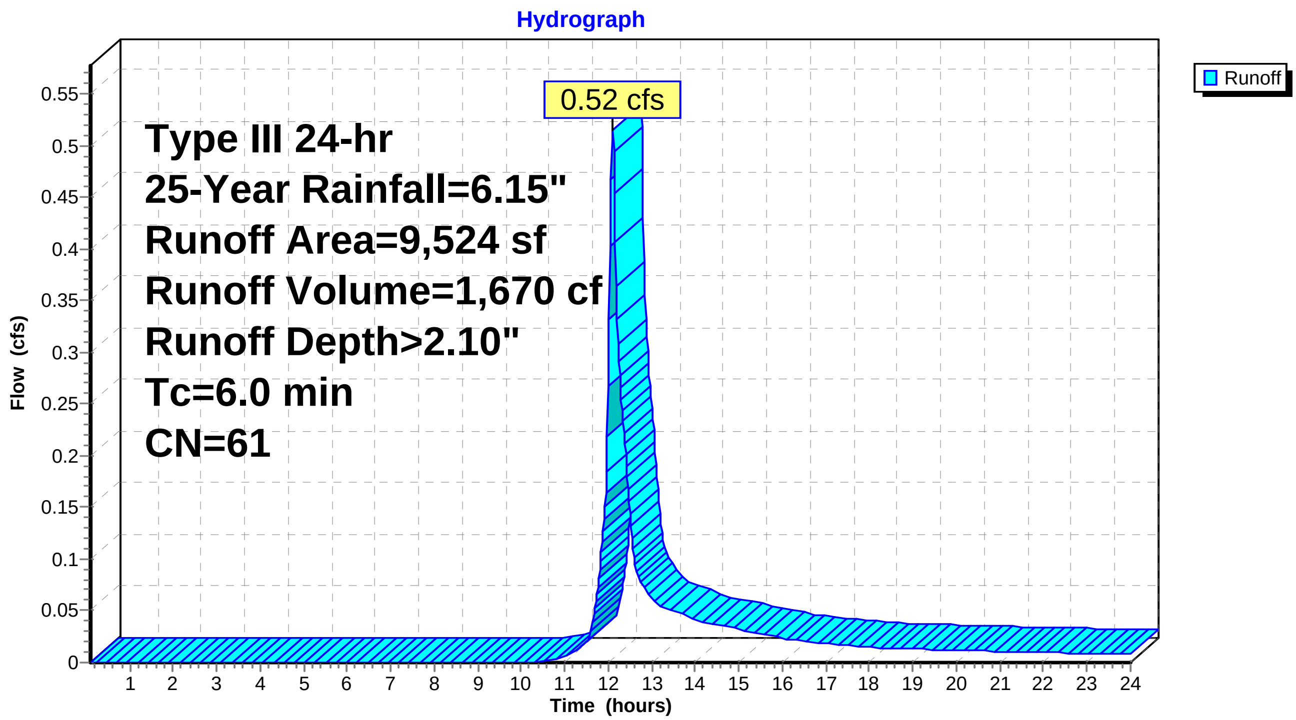
Runoff = 0.52 cfs @ 12.10 hrs, Volume= 1,670 cf, Depth> 2.10"

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=6.15"

Area (sf)	CN	Description
6,804	61	>75% Grass cover, Good, HSG B
2,720	60	Woods, Fair, HSG B
9,524	61	Weighted Average
9,524		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Pond 7R: Subsurface Structure

Inflow Area =	14,025 sf,100.00% Impervious,	Inflow Depth > 5.91" for 25-Year event			
Inflow =	1.94 cfs @	12.08 hrs,	Volume=	6,904 cf	
Outflow =	1.94 cfs @	12.08 hrs,	Volume=	6,256 cf,	Atten= 0%, Lag= 0.0 min
Discarded =	0.02 cfs @	3.48 hrs,	Volume=	1,320 cf	
Primary =	1.92 cfs @	12.08 hrs,	Volume=	4,935 cf	

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 199.52' @ 12.08 hrs Surf.Area= 705 sf Storage= 655 cf

Plug-Flow detention time= 72.7 min calculated for 6,250 cf (91% of inflow)
Center-of-Mass det. time= 25.3 min (769.5 - 744.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	197.70'	425 cf	**3.92'W x 180.00'L x 2.04'H Field A** 1,440 cf Overall - 377 cf Embedded = 1,063 cf x 40.0% Voids
#2A	198.03'	292 cf	**ADS N-12 12"** x 18 Inside #1 Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf 18 Chambers in 2 Rows
		717 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	197.70'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	199.50'	**180.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 3.48 hrs HW=197.72' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=1.83 cfs @ 12.08 hrs HW=199.52' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 1.83 cfs @ 0.48 fps)

Pond 7R: Subsurface Structure - Chamber Wizard Field A

Chamber Model = ADS N-12 12" (ADS N-12® Pipe)
Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf
Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf

14.5" Wide + 6.0" Spacing = 20.5" C-C Row Spacing

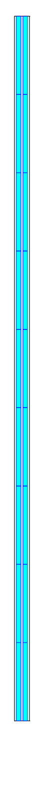
9 Chambers/Row x 20.00' Long = 180.00' Row Length
2 Rows x 14.5" Wide + 6.0" Spacing x 1 + 6.0" Side Stone x 2 = 3.92' Base Width
4.0" Base + 14.5" Chamber Height + 6.0" Cover = 2.04' Field Height

18 Chambers x 16.2 cf = 291.6 cf Chamber Storage
18 Chambers x 20.9 cf = 376.8 cf Displacement

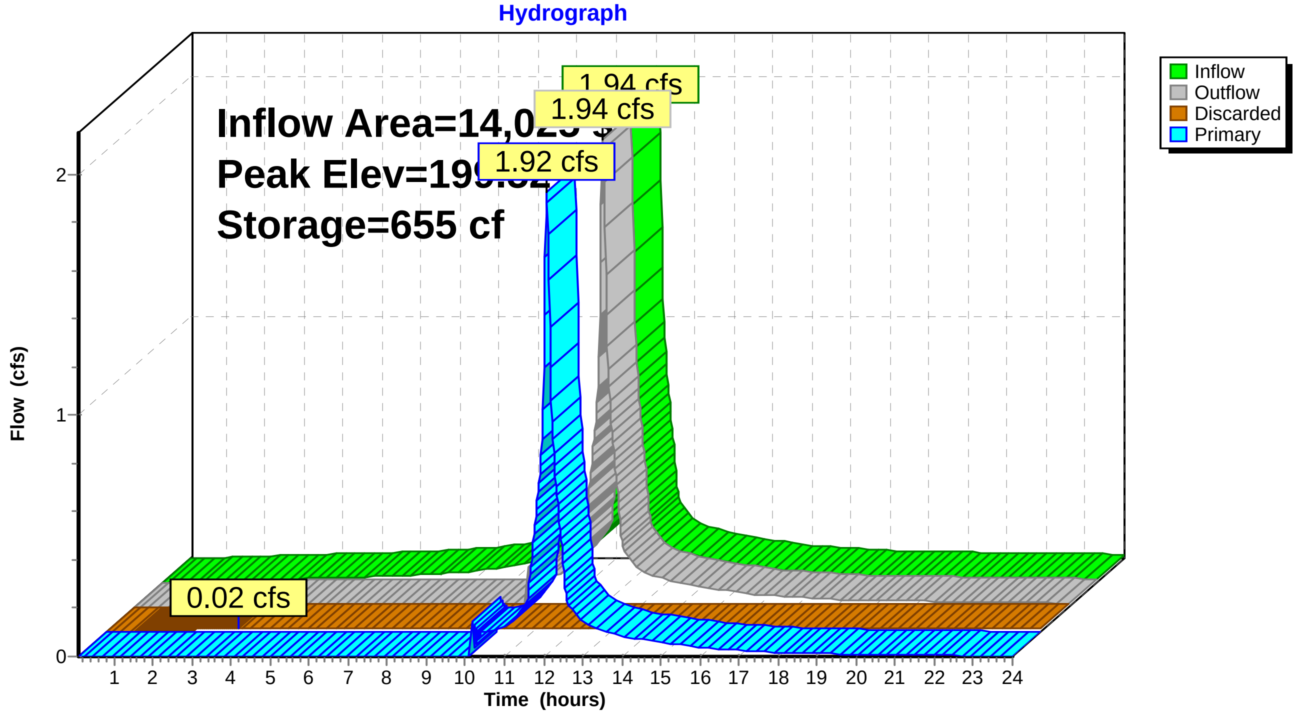
1,440.2 cf Field - 376.8 cf Chambers = 1,063.3 cf Stone x 40.0% Voids = 425.3 cf Stone Storage

Chamber Storage + Stone Storage = 716.9 cf = 0.016 af
Overall Storage Efficiency = 49.8%
Overall System Size = 180.00' x 3.92' x 2.04'

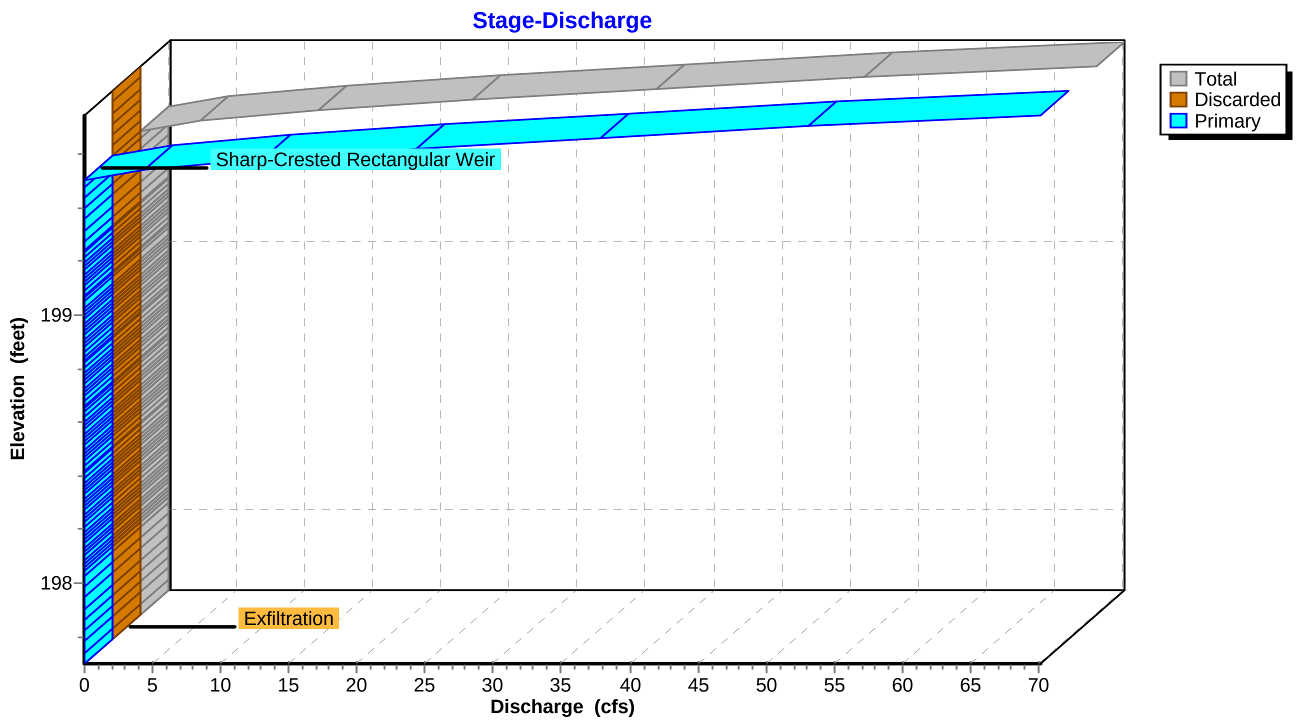
18 Chambers @ $ 0.00 /ea = $ 0.00
53.3 cy Field Excavation @ $ 10.00 /cy = $ 533.39
39.4 cy Stone @ $ 30.00 /cy = $ 1,181.47
Total Cost = $ 1,714.86



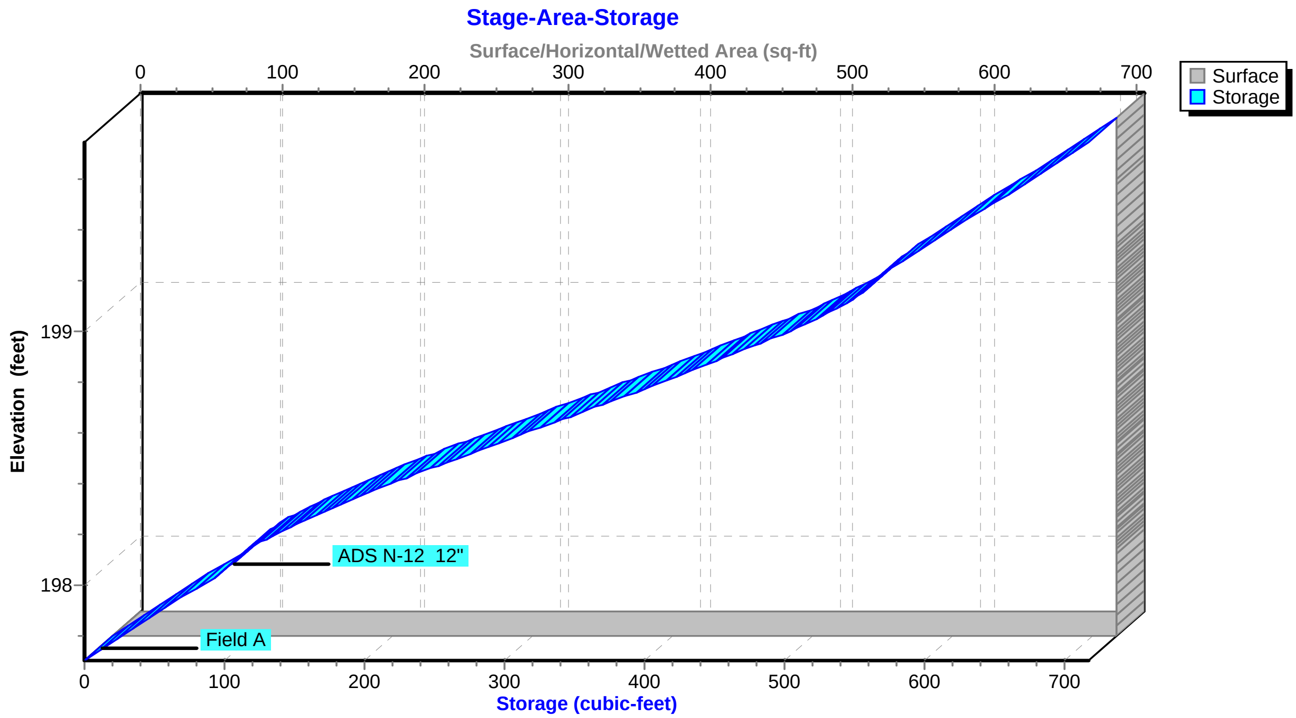
Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure



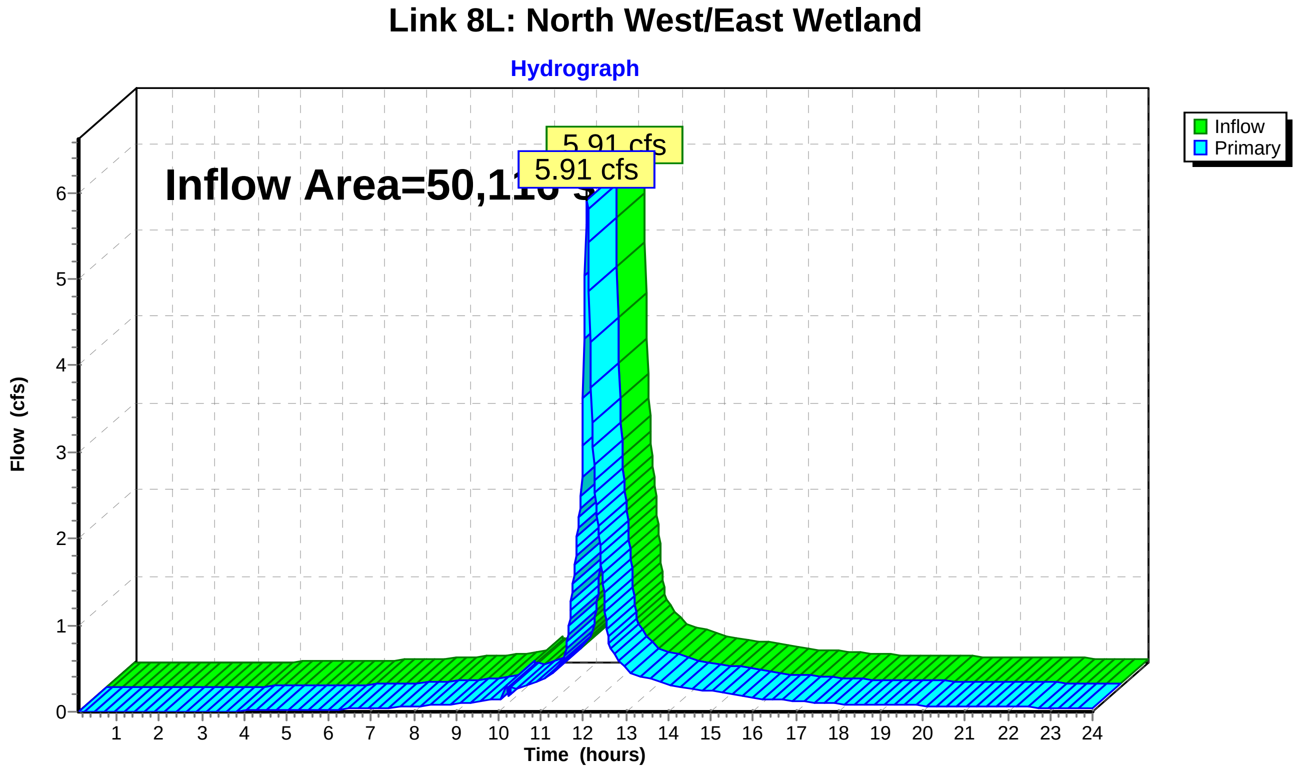
Pond 7R: Subsurface Structure



Summary for Link 8L: North West/East Wetland

Inflow Area =	50,116 sf,	43.40% Impervious,	Inflow Depth > 4.35"	for 25-Year event
Inflow =	5.91 cfs @	12.08 hrs, Volume=	18,153 cf	
Primary =	5.91 cfs @	12.08 hrs, Volume=	18,153 cf, Atten= 0%, Lag= 0.0 min	

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

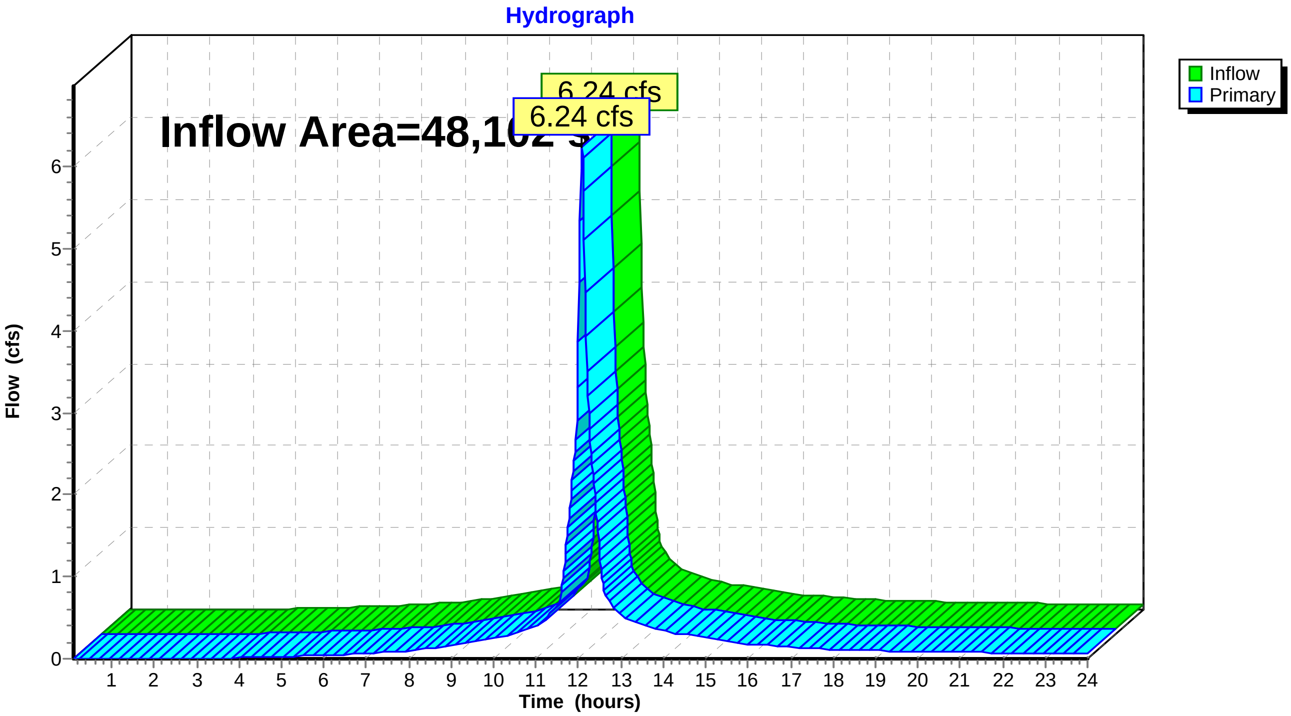


Summary for Link 9L: North West/East Wetland

Inflow Area =	48,102 sf, 45.29% Impervious,	Inflow Depth > 5.13"	for 25-Year event
Inflow =	6.24 cfs @ 12.08 hrs, Volume=	20,552 cf	
Primary =	6.24 cfs @ 12.08 hrs, Volume=	20,552 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 - To Catch Runoff Area=15,970 sf 57.94% Impervious Runoff Depth>5.66"
Tc=6.0 min CN=85 Runoff=2.36 cfs 7,532 cf

Subcatchment 1 PRE: Pre 1 - To Catch Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>5.89"
Tc=6.0 min CN=87 Runoff=2.73 cfs 8,830 cf

Subcatchment 2 POST: Post 2 Runoff Area=17,714 sf 38.51% Impervious Runoff Depth>6.71"
Tc=6.0 min CN=94 Runoff=2.90 cfs 9,905 cf

Subcatchment 2 PRE: Pre 2 Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>6.47"
Tc=6.0 min CN=92 Runoff=6.26 cfs 20,978 cf

Subcatchment 3 Post: Post 3 Runoff Area=8,853 sf 10.22% Impervious Runoff Depth>6.01"
Tc=6.0 min CN=88 Runoff=1.36 cfs 4,431 cf

Subcatchment 3 PRE: Pre 3 Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>6.01"
Tc=6.0 min CN=88 Runoff=1.42 cfs 4,616 cf

Subcatchment 4 POST: Post 4 Runoff Area=14,025 sf 100.00% Impervious Runoff Depth>7.19"
Tc=6.0 min CN=98 Runoff=2.34 cfs 8,398 cf

Subcatchment 5 POST: Post 5 Runoff Area=9,524 sf 0.00% Impervious Runoff Depth>3.01"
Tc=6.0 min CN=61 Runoff=0.76 cfs 2,391 cf

Pond 7R: Subsurface Structure Peak Elev=199.52' Storage=655 cf Inflow=2.34 cfs 8,398 cf
Discarded=0.02 cfs 1,350 cf Primary=2.33 cfs 6,400 cf Outflow=2.34 cfs 7,749 cf

Link 8L: North West/East Wetland Inflow=7.34 cfs 23,127 cf
Primary=7.34 cfs 23,127 cf

Link 9L: North West/East Wetland Inflow=7.68 cfs 25,593 cf
Primary=7.68 cfs 25,593 cf

Total Runoff Area = 132,176 sf Runoff Volume = 67,081 cf Average Runoff Depth = 6.09"
51.40% Pervious = 67,936 sf 48.60% Impervious = 64,240 sf

Summary for Subcatchment 1 POST: Post 1 - To Catch Basin

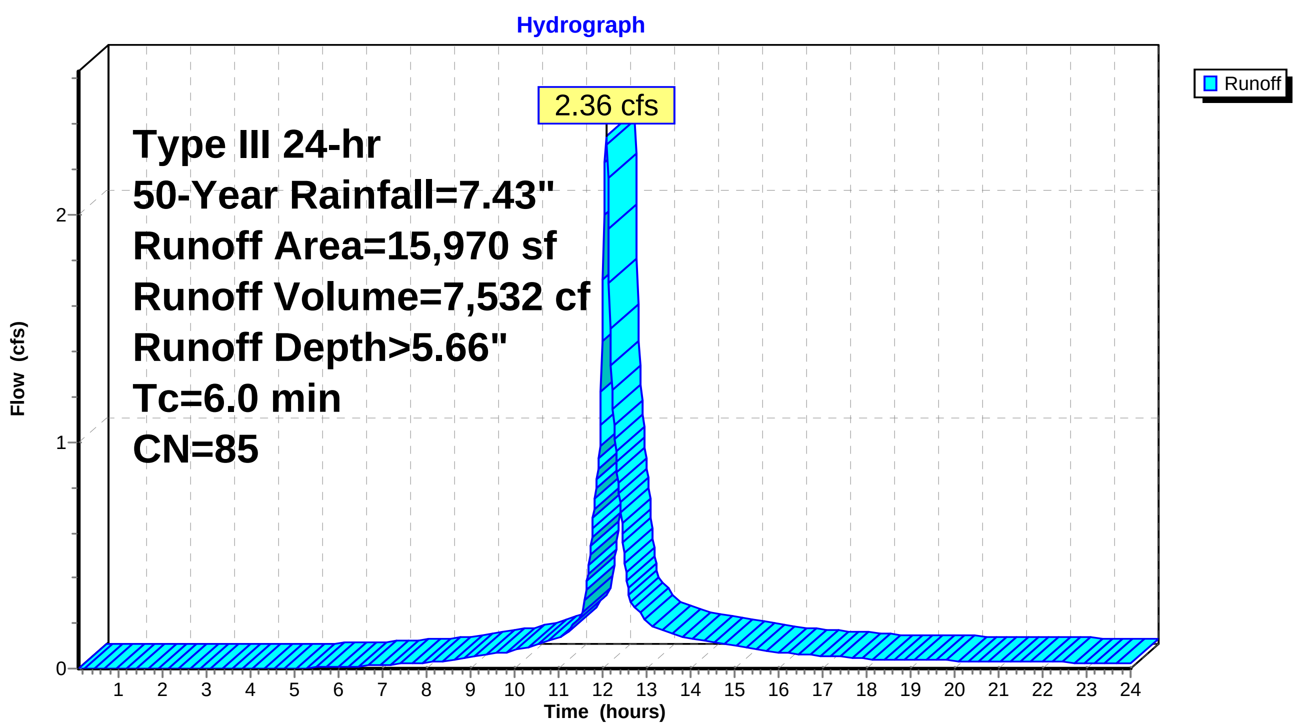
Runoff = 2.36 cfs @ 12.09 hrs, Volume= 7,532 cf, Depth> 5.66"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
5,953	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
9,253	98	Paved parking, HSG B
15,970	85	Weighted Average
6,717		42.06% Pervious Area
9,253		57.94% Impervious Area

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

Subcatchment 1 POST: Post 1 - To Catch Basin



Summary for Subcatchment 1 PRE: Pre 1 - To Catch Basin

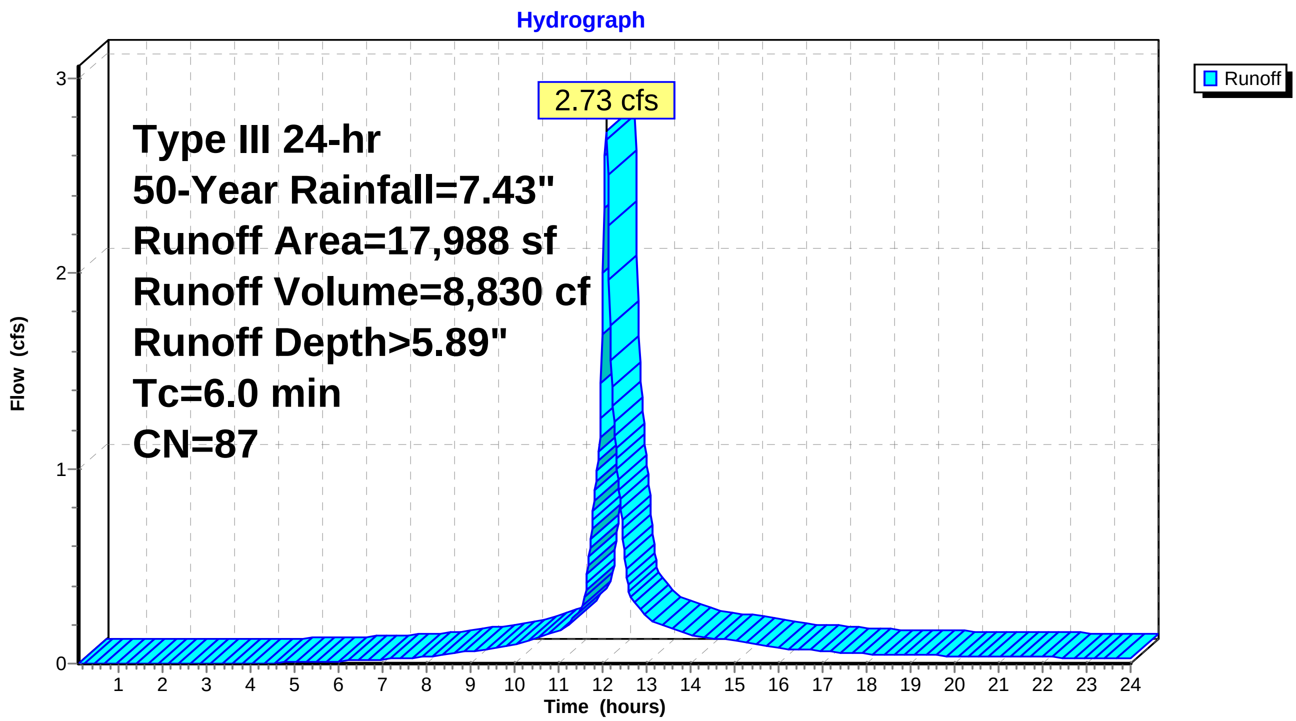
Runoff = 2.73 cfs @ 12.08 hrs, Volume= 8,830 cf, Depth> 5.89"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
5,774	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
11,450	98	Paved parking, HSG B
17,988	87	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
6.0					**Direct Entry,**

Subcatchment 1 PRE: Pre 1 - To Catch Basin



Summary for Subcatchment 2 POST: Post 2

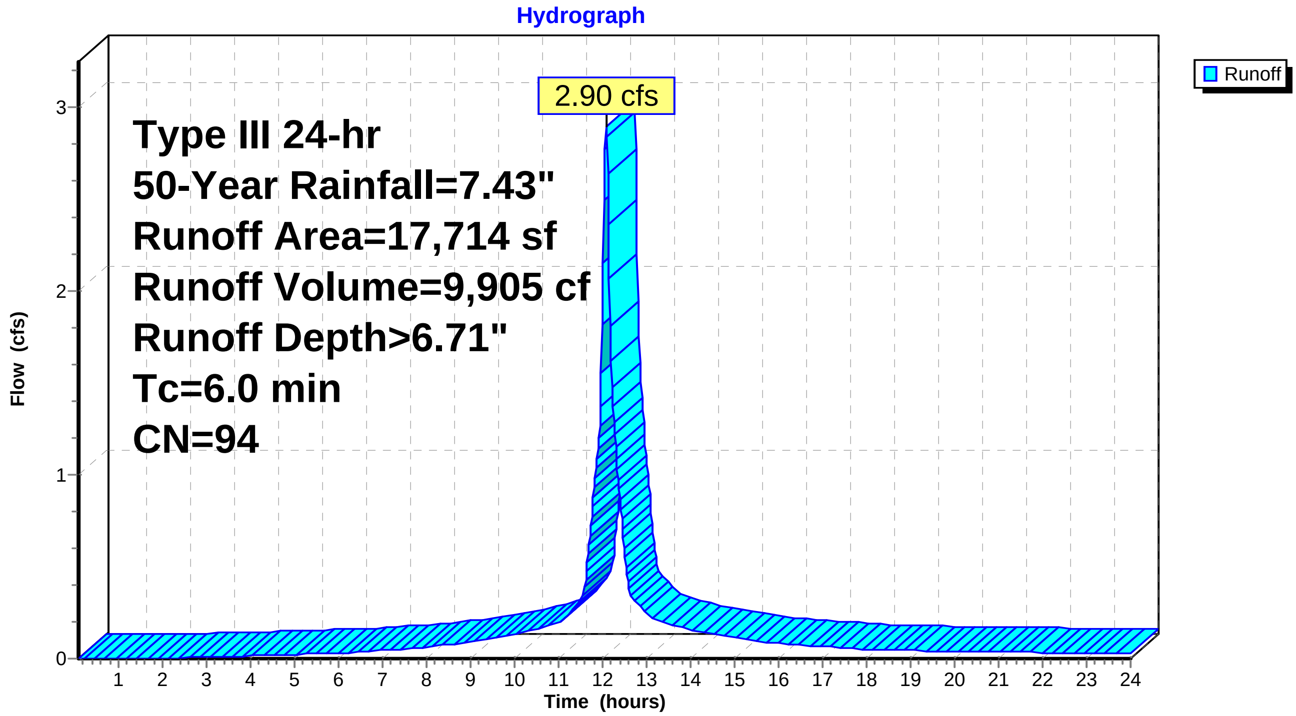
Runoff = 2.90 cfs @ 12.08 hrs, Volume= 9,905 cf, Depth> 6.71"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
1,563	60	Woods, Fair, HSG B
6,822	98	Paved parking, HSG B
9,329	96	Gravel surface, HSG B
17,714	94	Weighted Average
10,892		61.49% Pervious Area
6,822		38.51% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

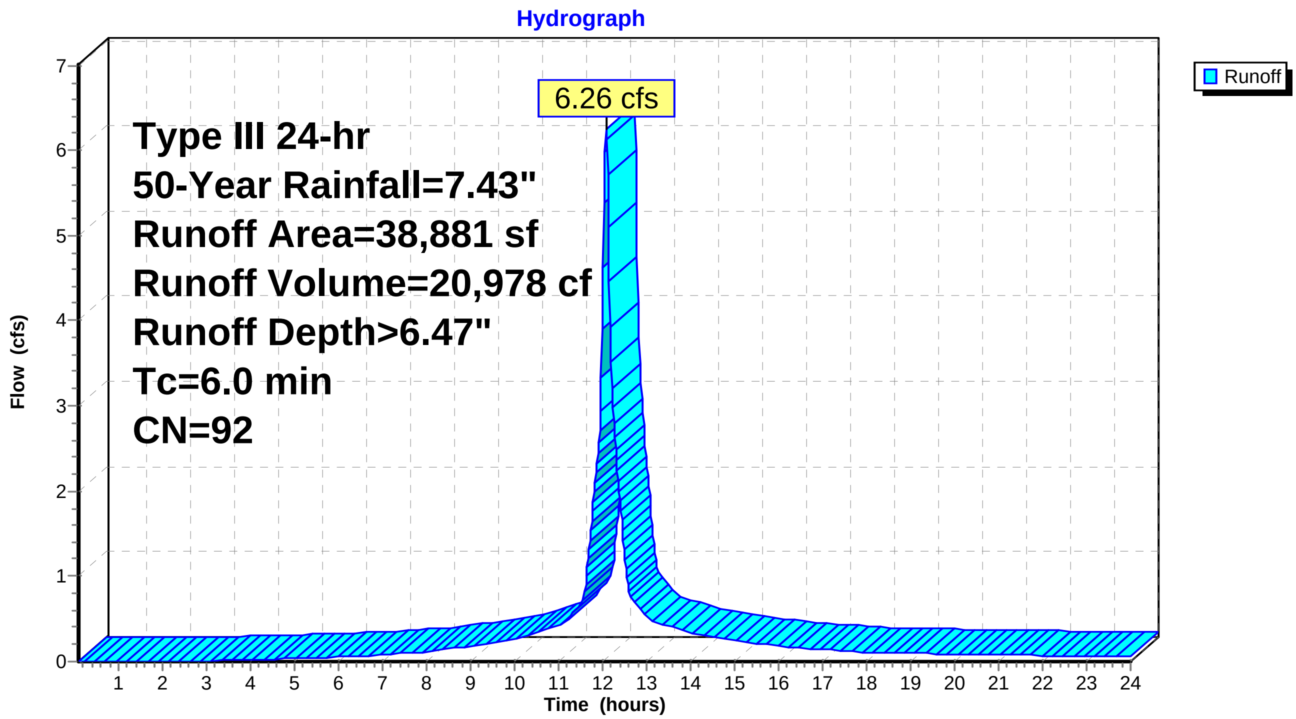
Runoff = 6.26 cfs @ 12.08 hrs, Volume= 20,978 cf, Depth> 6.47"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
4,958	60	Woods, Fair, HSG B
6,631	98	Roofs, HSG B
13,977	98	Paved parking, HSG B
13,315	96	Gravel surface, HSG B
38,881	92	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
6.0					**Direct Entry,**

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

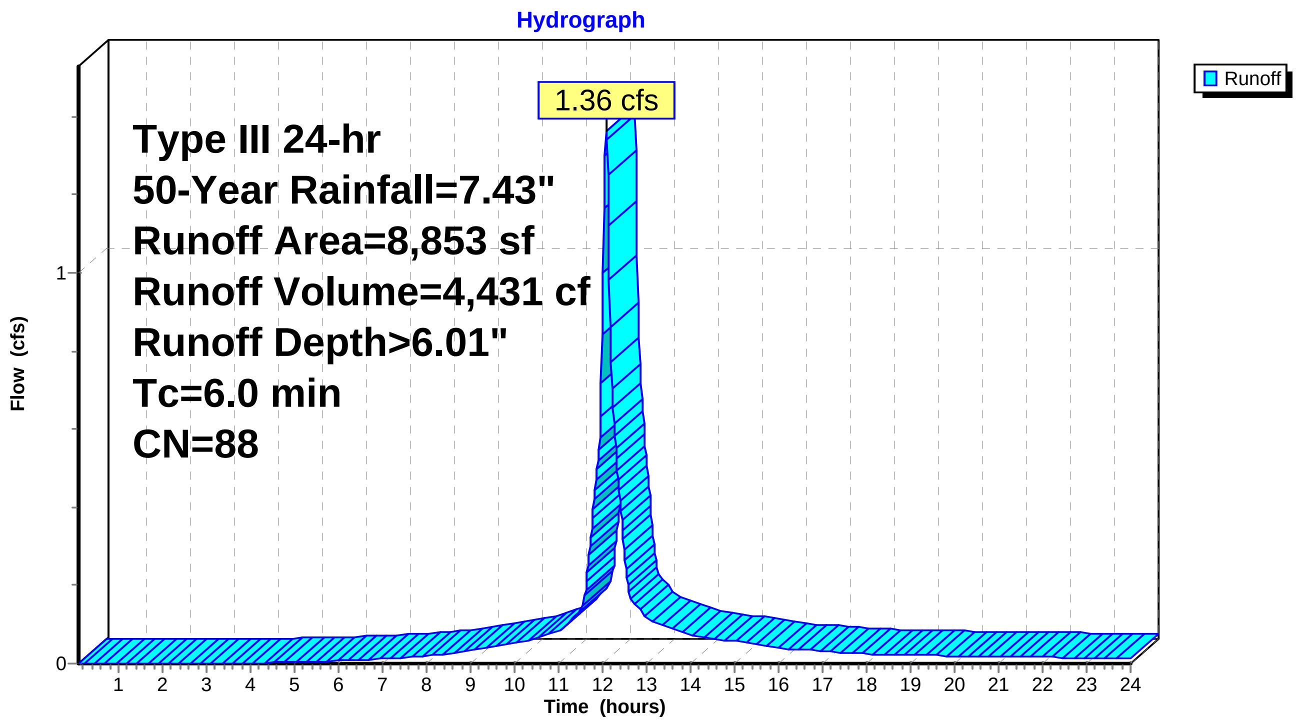
Runoff = 1.36 cfs @ 12.08 hrs, Volume= 4,431 cf, Depth> 6.01"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
5,832	96	Gravel surface, HSG B
905	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
8,853	88	Weighted Average
7,948		89.78% Pervious Area
905		10.22% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

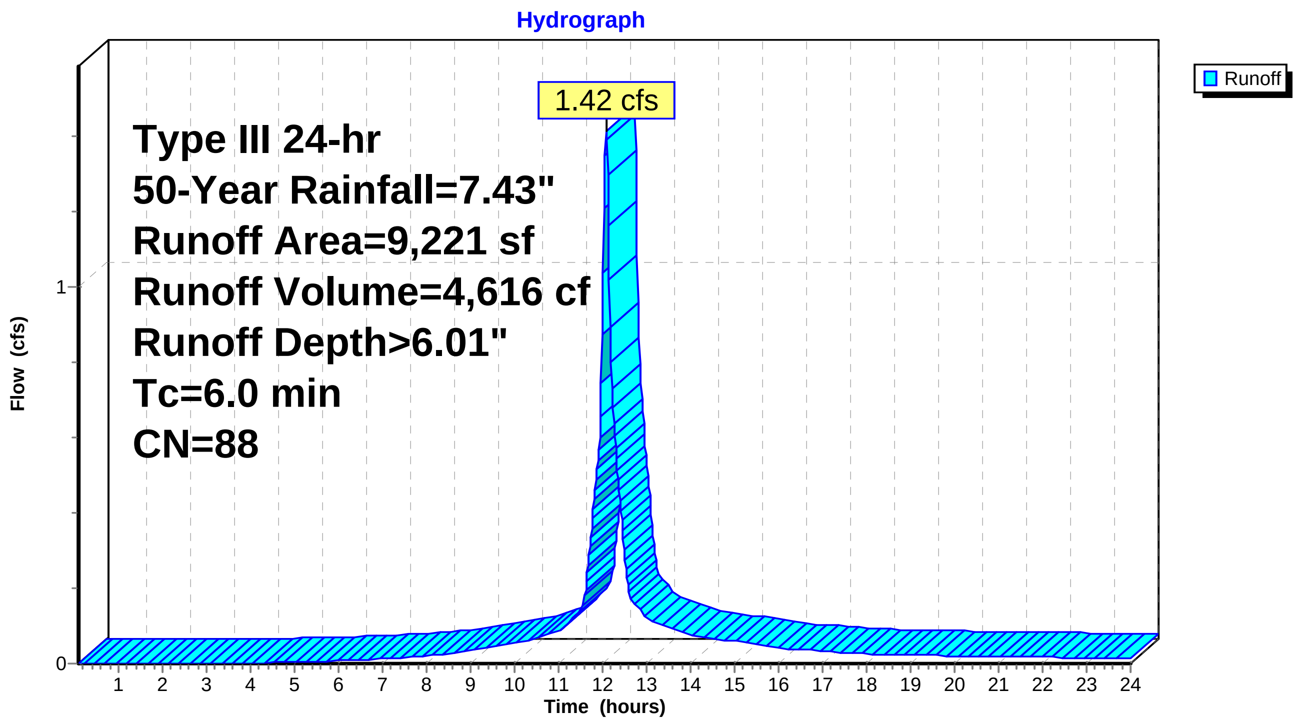
Runoff = 1.42 cfs @ 12.08 hrs, Volume= 4,616 cf, Depth> 6.01"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG B
1,177	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
9,221	88	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
6.0					**Direct Entry,**

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

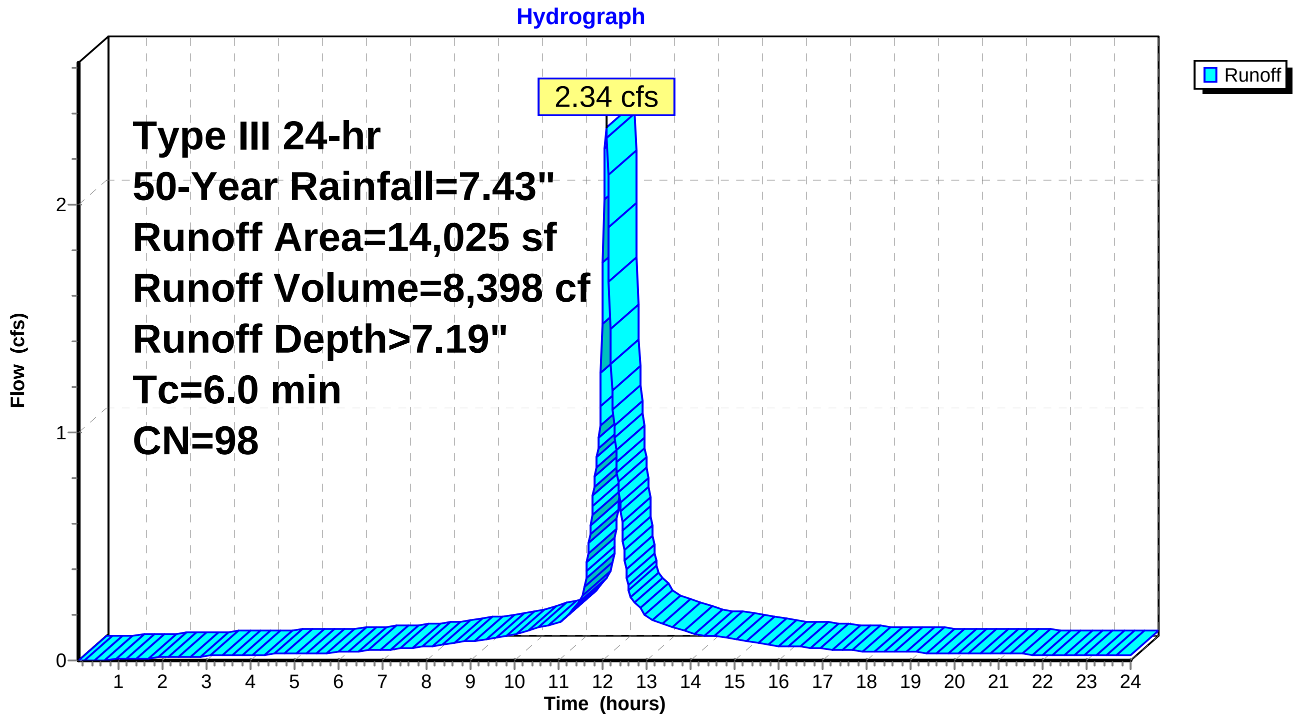
Runoff = 2.34 cfs @ 12.08 hrs, Volume= 8,398 cf, Depth> 7.19"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
14,025	98	Unconnected roofs, HSG B
14,025		100.00% Impervious Area
14,025		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

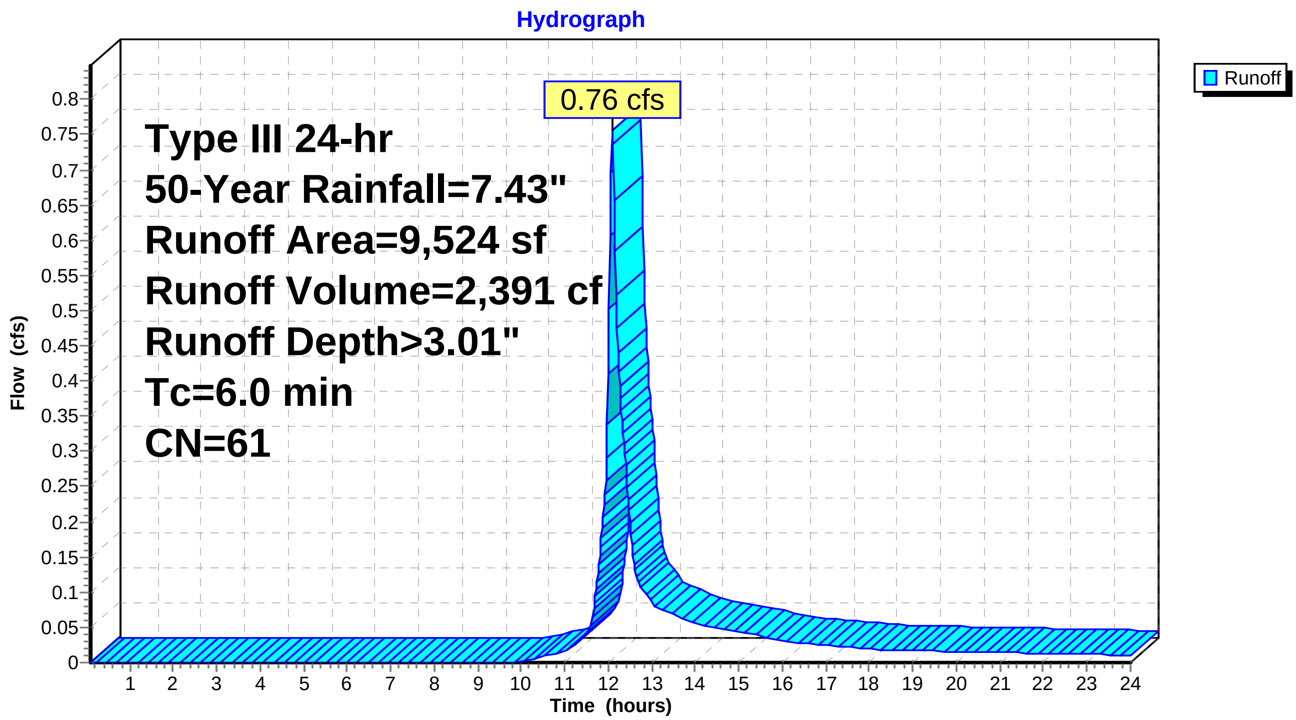
Runoff = 0.76 cfs @ 12.09 hrs, Volume= 2,391 cf, Depth> 3.01"

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 50-Year Rainfall=7.43"

Area (sf)	CN	Description
6,804	61	>75% Grass cover, Good, HSG B
2,720	60	Woods, Fair, HSG B
9,524	61	Weighted Average
9,524		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Pond 7R: Subsurface Structure

Inflow Area = 14,025 sf,100.00% Impervious, Inflow Depth > 7.19" for 50-Year event
Inflow = 2.34 cfs @ 12.08 hrs, Volume= 8,398 cf
Outflow = 2.34 cfs @ 12.08 hrs, Volume= 7,749 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.02 cfs @ 2.62 hrs, Volume= 1,350 cf
Primary = 2.33 cfs @ 12.08 hrs, Volume= 6,400 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 199.52' @ 12.08 hrs Surf.Area= 705 sf Storage= 655 cf

Plug-Flow detention time= 66.3 min calculated for 7,749 cf (92% of inflow)
Center-of-Mass det. time= 24.8 min (766.5 - 741.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	197.70'	425 cf	**3.92'W x 180.00'L x 2.04'H Field A** 1,440 cf Overall - 377 cf Embedded = 1,063 cf x 40.0% Voids
#2A	198.03'	292 cf	**ADS N-12 12"** x 18 Inside #1 Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf 18 Chambers in 2 Rows
		717 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	197.70'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	199.50'	**180.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 2.62 hrs HW=197.72' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=2.19 cfs @ 12.08 hrs HW=199.52' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 2.19 cfs @ 0.51 fps)

Pond 7R: Subsurface Structure - Chamber Wizard Field A

Chamber Model = ADS N-12 12" (ADS N-12® Pipe)
Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf
Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf

14.5" Wide + 6.0" Spacing = 20.5" C-C Row Spacing

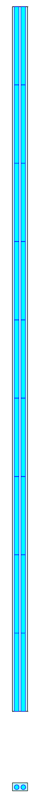
9 Chambers/Row x 20.00' Long = 180.00' Row Length
2 Rows x 14.5" Wide + 6.0" Spacing x 1 + 6.0" Side Stone x 2 = 3.92' Base Width
4.0" Base + 14.5" Chamber Height + 6.0" Cover = 2.04' Field Height

18 Chambers x 16.2 cf = 291.6 cf Chamber Storage
18 Chambers x 20.9 cf = 376.8 cf Displacement

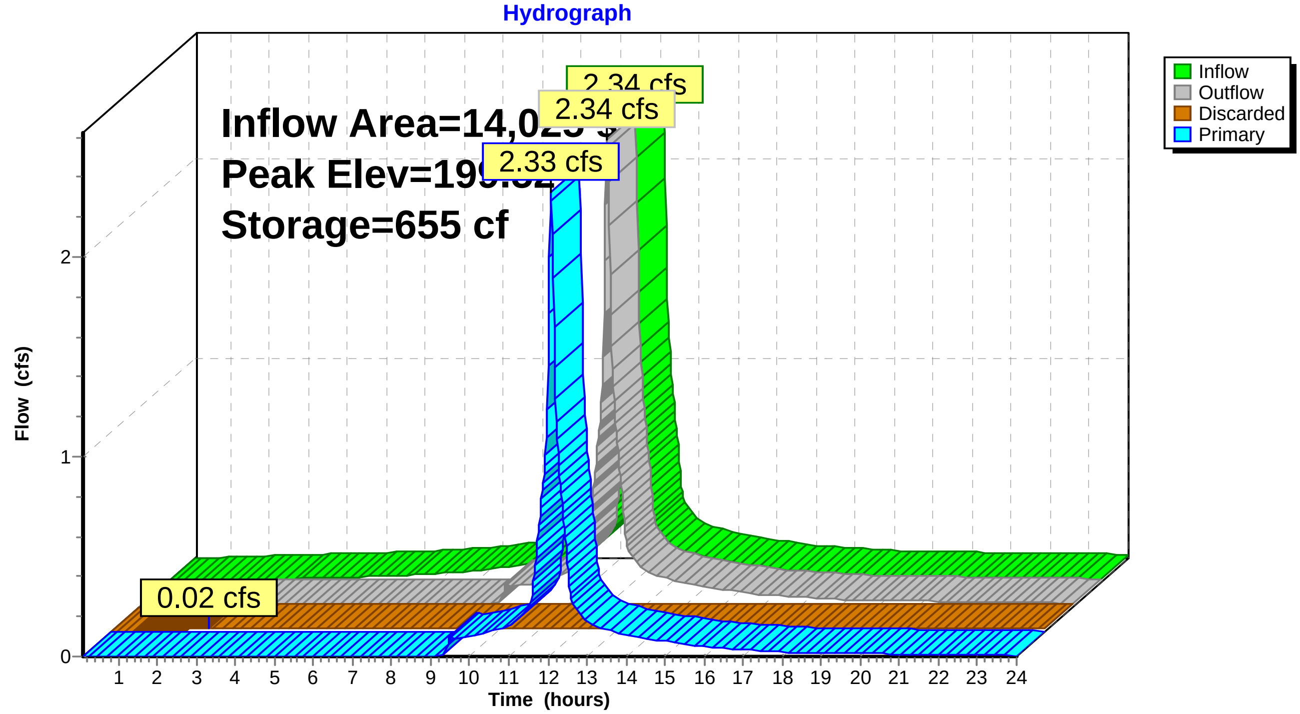
1,440.2 cf Field - 376.8 cf Chambers = 1,063.3 cf Stone x 40.0% Voids = 425.3 cf Stone Storage

Chamber Storage + Stone Storage = 716.9 cf = 0.016 af
Overall Storage Efficiency = 49.8%
Overall System Size = 180.00' x 3.92' x 2.04'

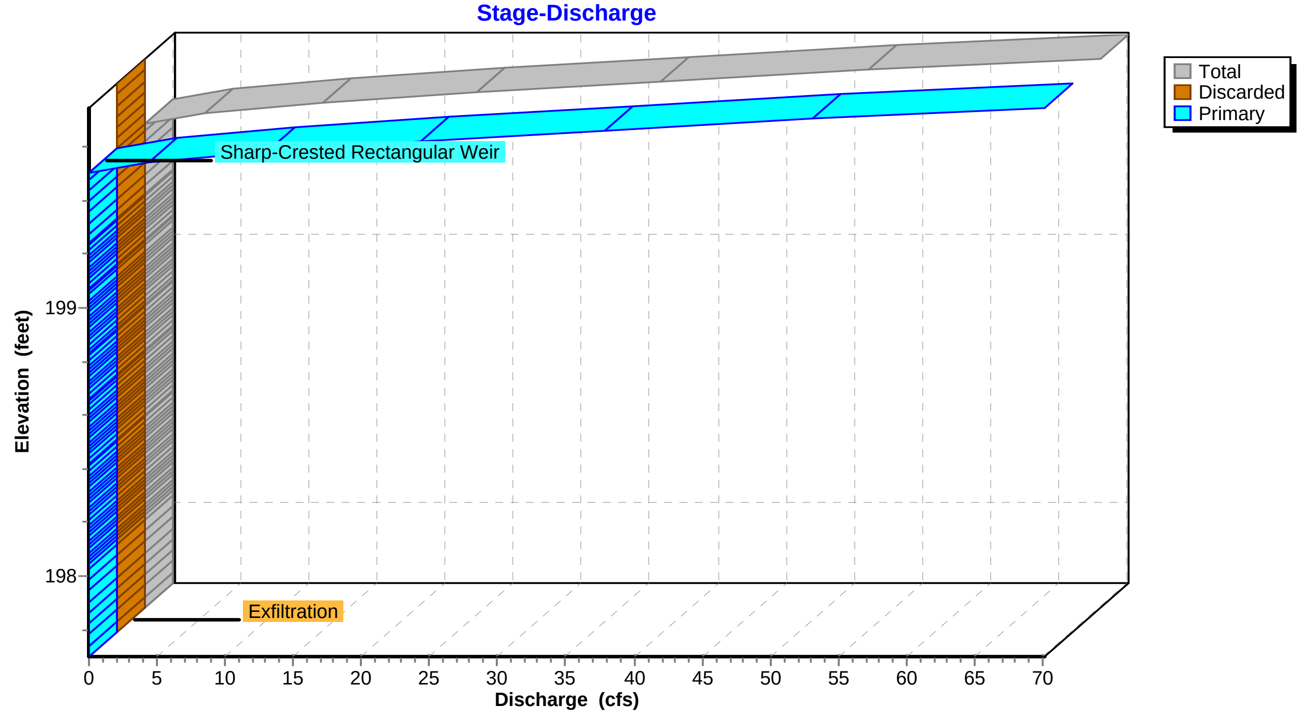
18 Chambers @ $ 0.00 /ea = $ 0.00
53.3 cy Field Excavation @ $ 10.00 /cy = $ 533.39
39.4 cy Stone @ $ 30.00 /cy = $ 1,181.47
Total Cost = $ 1,714.86



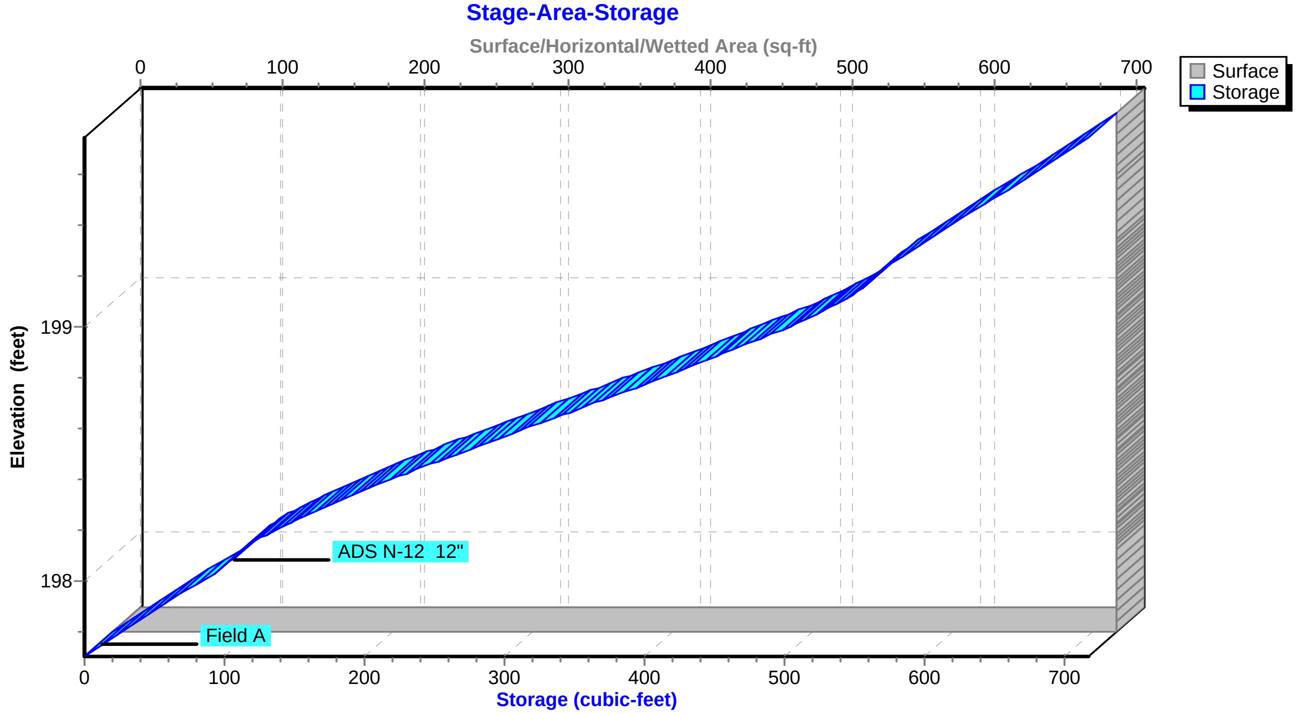
Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure

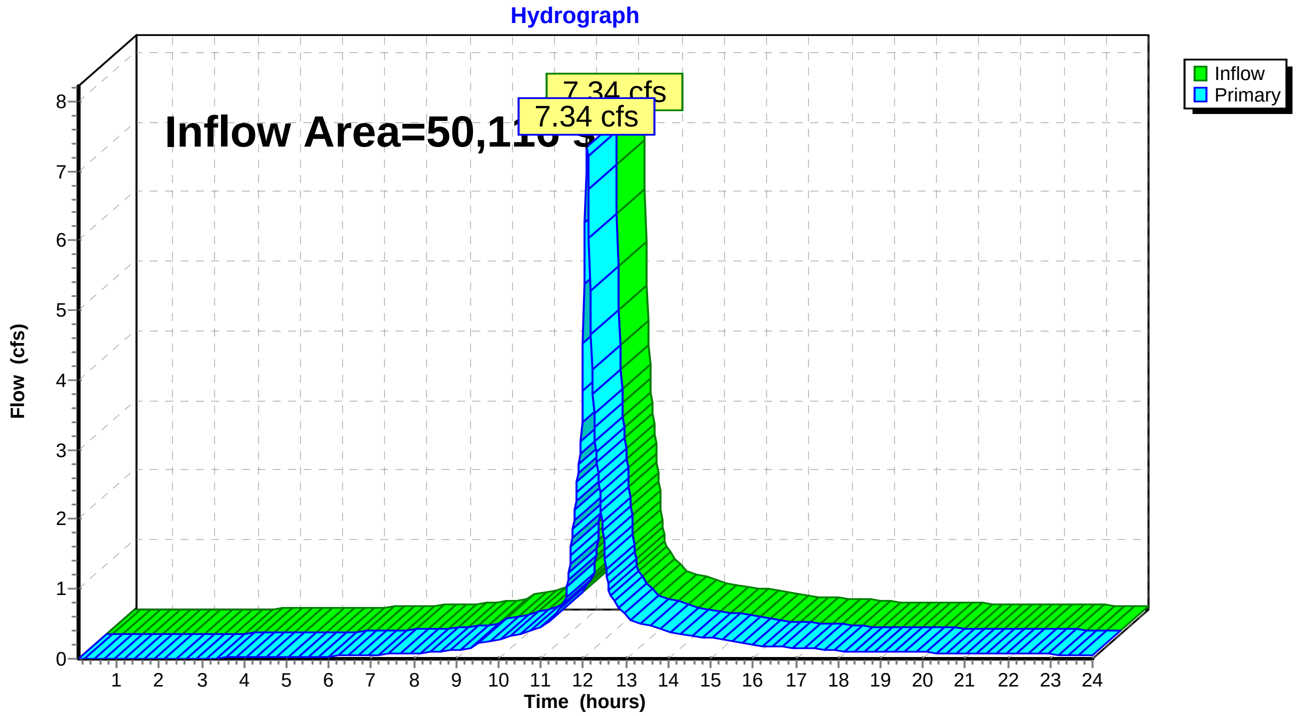


Summary for Link 8L: North West/East Wetland

Inflow Area = 50,116 sf, 43.40% Impervious, Inflow Depth > 5.54" for 50-Year event
Inflow = 7.34 cfs @ 12.08 hrs, Volume= 23,127 cf
Primary = 7.34 cfs @ 12.08 hrs, Volume= 23,127 cf, Atten= 0%, Lag= 0.0 min

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

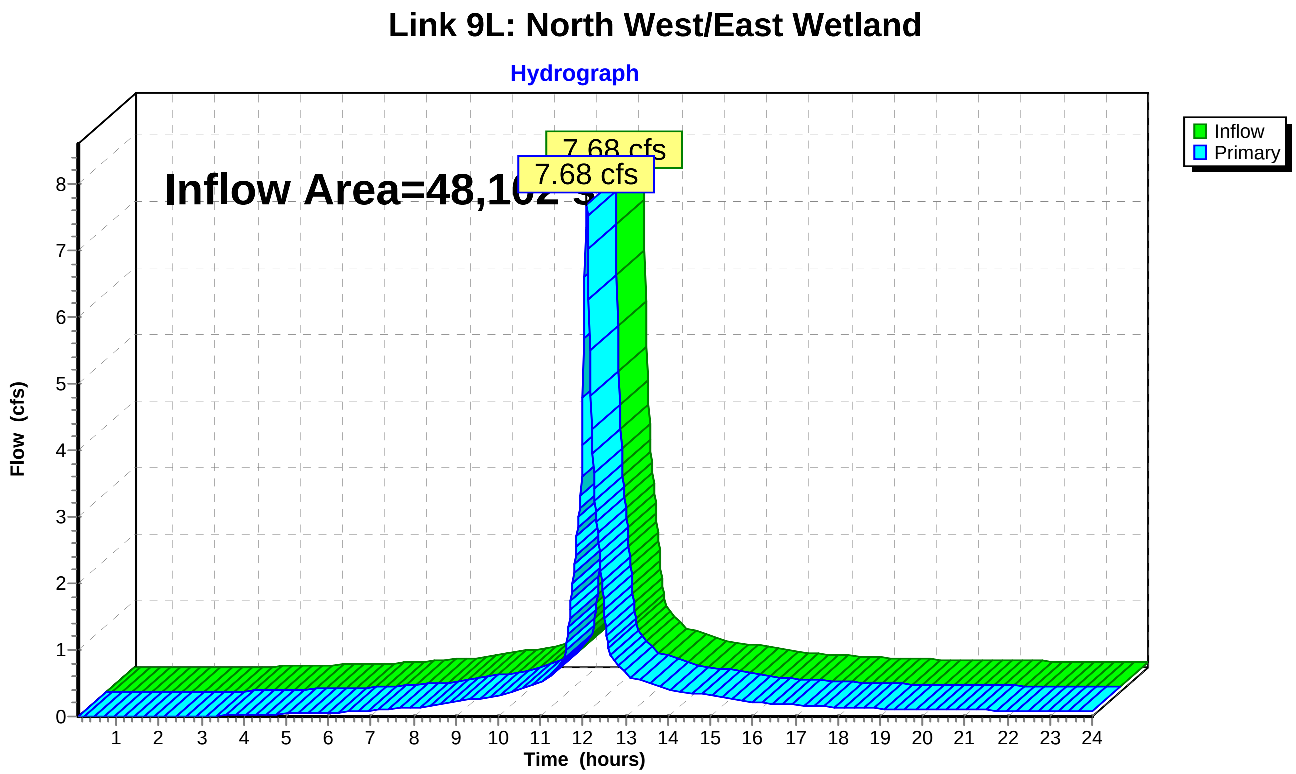
Link 8L: North West/East Wetland



Summary for Link 9L: North West/East Wetland

Inflow Area = 48,102 sf, 45.29% Impervious, Inflow Depth > 6.38" for 50-Year event
Inflow = 7.68 cfs @ 12.08 hrs, Volume= 25,593 cf
Primary = 7.68 cfs @ 12.08 hrs, Volume= 25,593 cf, Atten= 0%, Lag= 0.0 min

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



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 - To Catch Runoff Area=15,970 sf 57.94% Impervious Runoff Depth>6.98"
Tc=6.0 min CN=85 Runoff=2.87 cfs 9,291 cf

Subcatchment 1 PRE: Pre 1 - To Catch Runoff Area=17,988 sf 63.65% Impervious Runoff Depth>7.22"
Tc=6.0 min CN=87 Runoff=3.31 cfs 10,829 cf

Subcatchment 2 POST: Post 2 Runoff Area=17,714 sf 38.51% Impervious Runoff Depth>8.07"
Tc=6.0 min CN=94 Runoff=3.46 cfs 11,915 cf

Subcatchment 2 PRE: Pre 2 Runoff Area=38,881 sf 53.00% Impervious Runoff Depth>7.83"
Tc=6.0 min CN=92 Runoff=7.49 cfs 25,370 cf

Subcatchment 3 Post: Post 3 Runoff Area=8,853 sf 10.22% Impervious Runoff Depth>7.35"
Tc=6.0 min CN=88 Runoff=1.65 cfs 5,419 cf

Subcatchment 3 PRE: Pre 3 Runoff Area=9,221 sf 12.76% Impervious Runoff Depth>7.35"
Tc=6.0 min CN=88 Runoff=1.72 cfs 5,644 cf

Subcatchment 4 POST: Post 4 Runoff Area=14,025 sf 100.00% Impervious Runoff Depth>8.55"
Tc=6.0 min CN=98 Runoff=2.78 cfs 9,997 cf

Subcatchment 5 POST: Post 5 Runoff Area=9,524 sf 0.00% Impervious Runoff Depth>4.06"
Tc=6.0 min CN=61 Runoff=1.03 cfs 3,223 cf

Pond 7R: Subsurface Structure Peak Elev=199.53' Storage=656 cf Inflow=2.78 cfs 9,997 cf
Discarded=0.02 cfs 1,370 cf Primary=2.76 cfs 7,978 cf Outflow=2.78 cfs 9,348 cf

Link 8L: North West/East Wetland Inflow=8.90 cfs 28,535 cf
Primary=8.90 cfs 28,535 cf

Link 9L: North West/East Wetland Inflow=9.21 cfs 31,014 cf
Primary=9.21 cfs 31,014 cf

Total Runoff Area = 132,176 sf Runoff Volume = 81,688 cf Average Runoff Depth = 7.42"
51.40% Pervious = 67,936 sf 48.60% Impervious = 64,240 sf

Summary for Subcatchment 1 POST: Post 1 - To Catch Basin

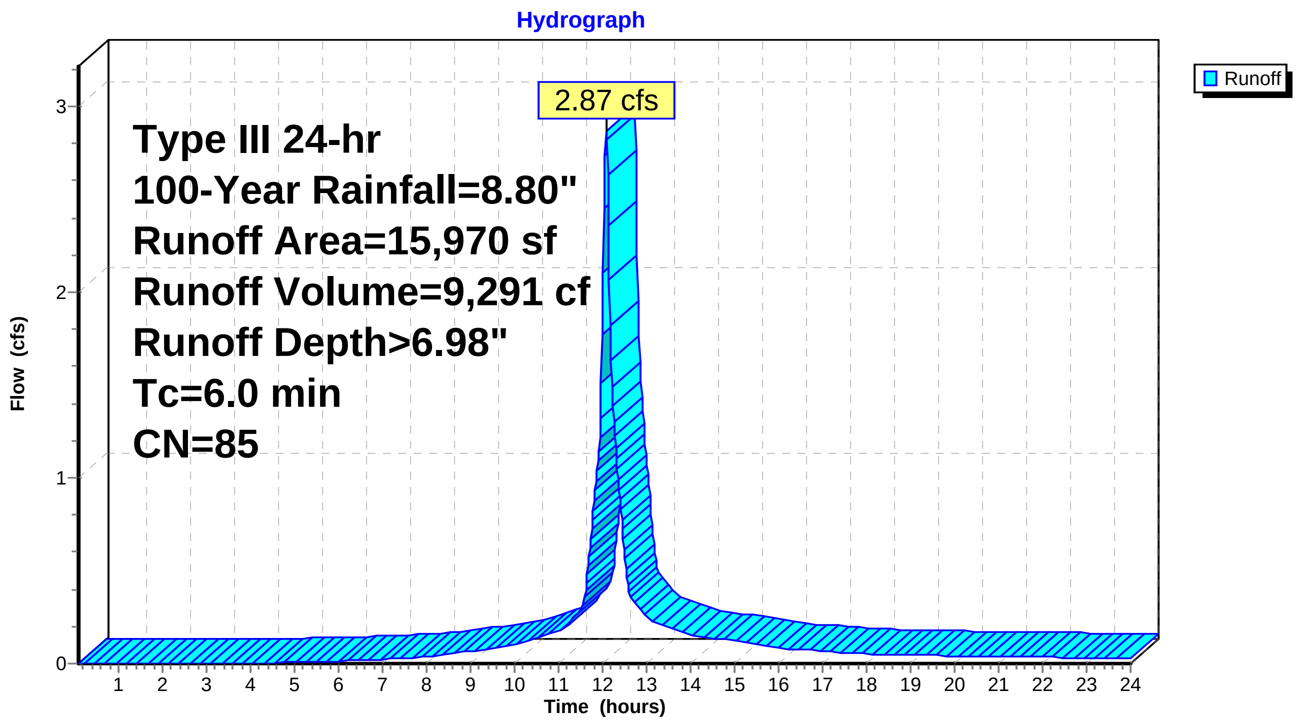
Runoff = 2.87 cfs @ 12.08 hrs, Volume= 9,291 cf, Depth> 6.98"

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=8.80"

Area (sf)	CN	Description
5,953	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
9,253	98	Paved parking, HSG B
15,970	85	Weighted Average
6,717		42.06% Pervious Area
9,253		57.94% Impervious Area

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

Subcatchment 1 POST: Post 1 - To Catch Basin



Summary for Subcatchment 1 PRE: Pre 1 - To Catch Basin

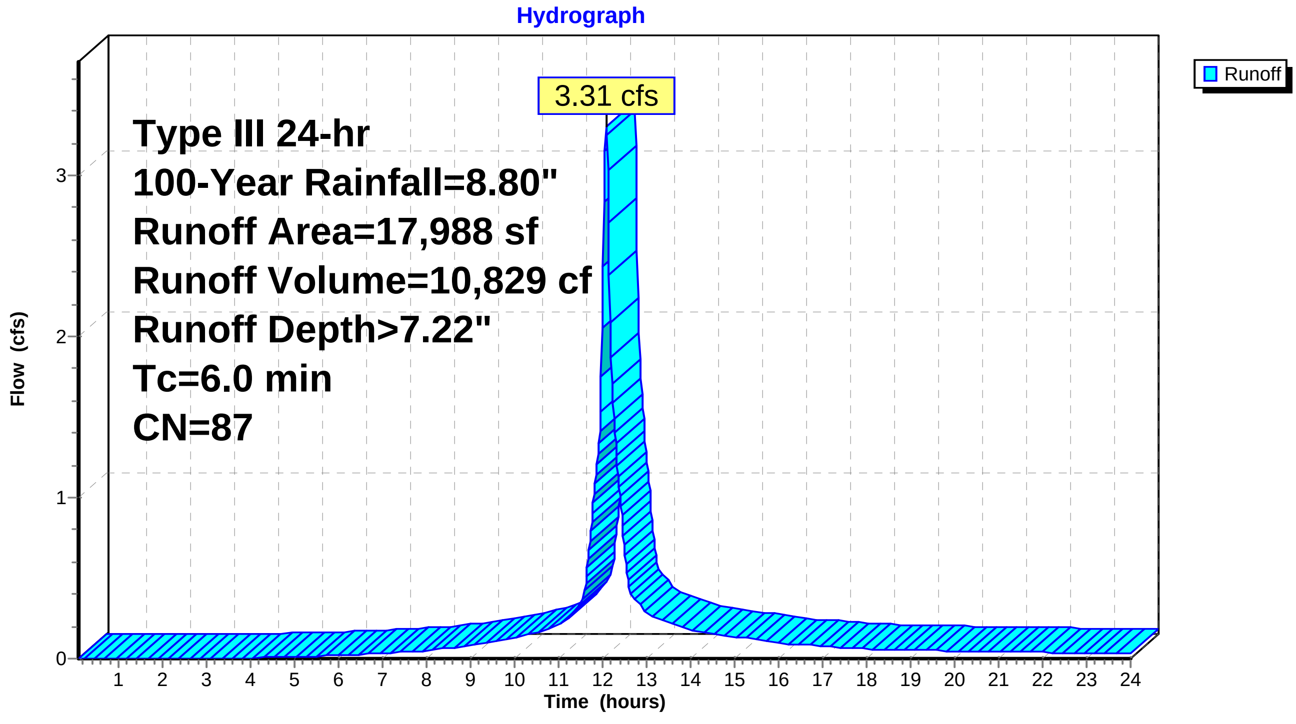
Runoff = 3.31 cfs @ 12.08 hrs, Volume= 10,829 cf, Depth> 7.22"

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=8.80"

Area (sf)	CN	Description
5,774	69	50-75% Grass cover, Fair, HSG B
764	60	Woods, Fair, HSG B
11,450	98	Paved parking, HSG B
17,988	87	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
6.0					**Direct Entry,**

Subcatchment 1 PRE: Pre 1 - To Catch Basin



Summary for Subcatchment 2 POST: Post 2

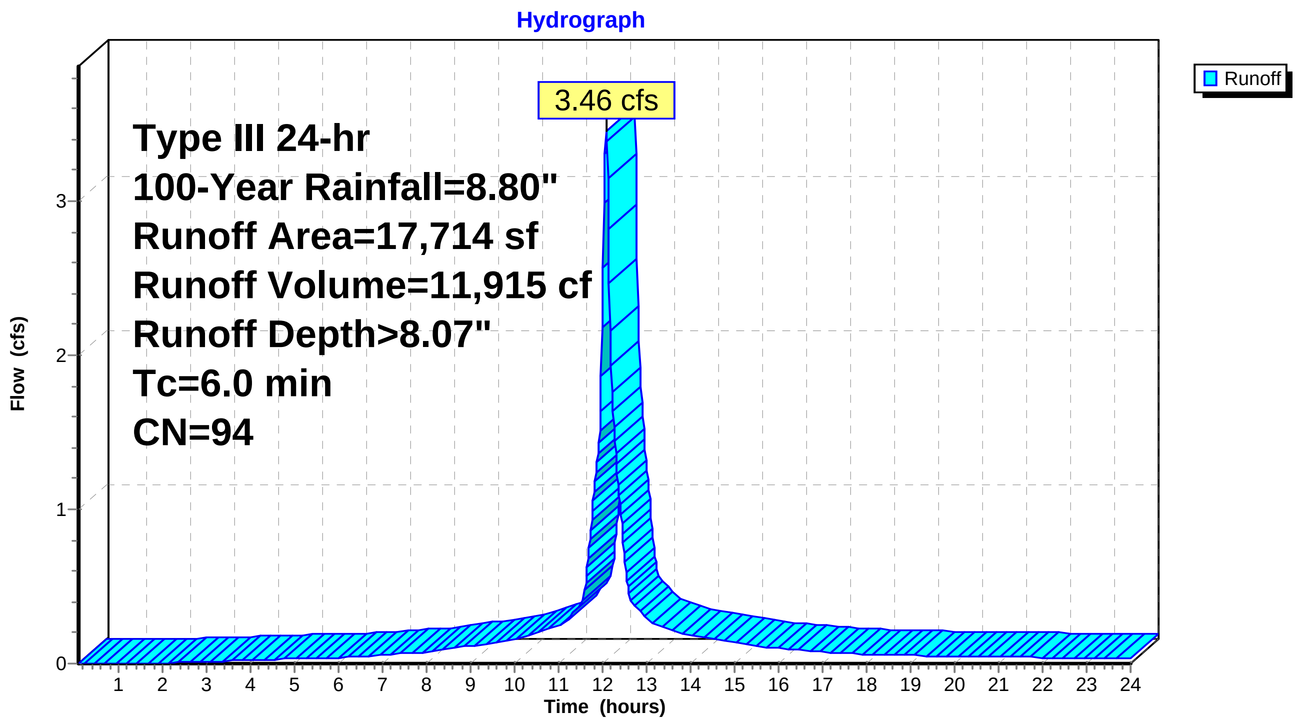
Runoff = 3.46 cfs @ 12.08 hrs, Volume= 11,915 cf, Depth> 8.07"

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=8.80"

Area (sf)	CN	Description
1,563	60	Woods, Fair, HSG B
6,822	98	Paved parking, HSG B
9,329	96	Gravel surface, HSG B
17,714	94	Weighted Average
10,892		61.49% Pervious Area
6,822		38.51% Impervious Area

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

Subcatchment 2 POST: Post 2



Summary for Subcatchment 2 PRE: Pre 2

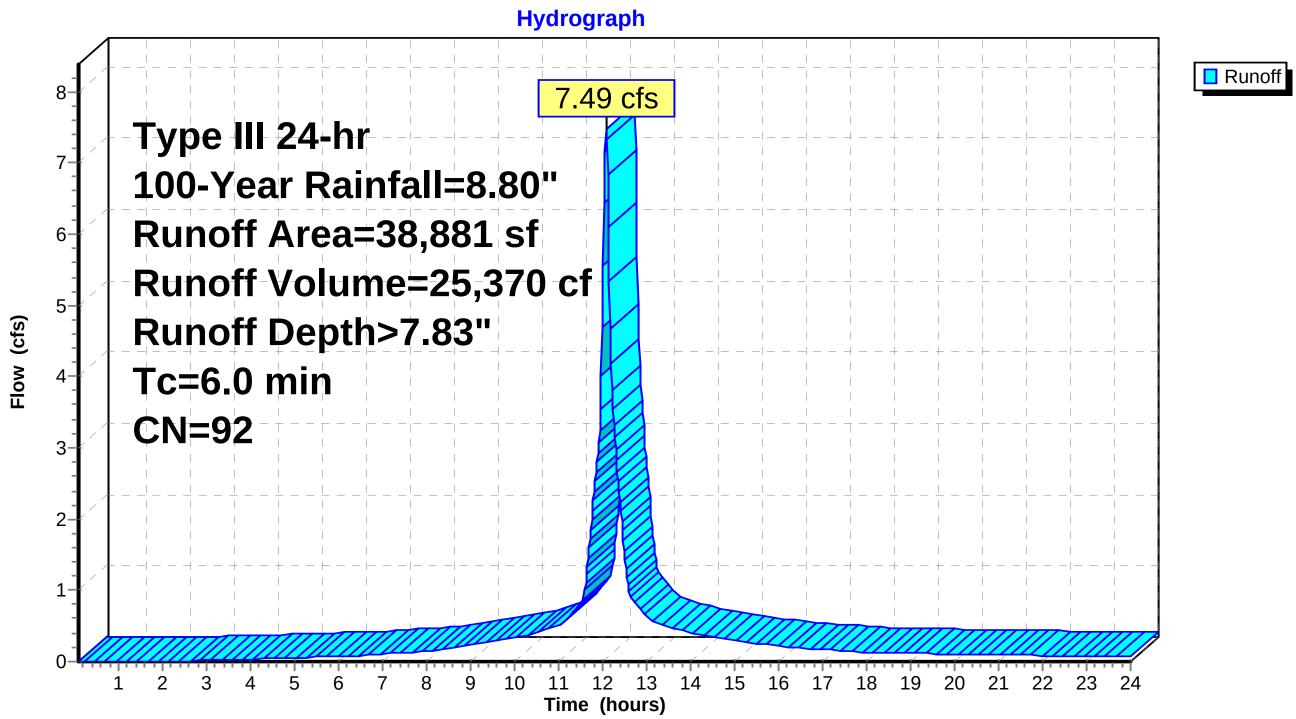
Runoff = 7.49 cfs @ 12.08 hrs, Volume= 25,370 cf, Depth> 7.83"

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=8.80"

Area (sf)	CN	Description
4,958	60	Woods, Fair, HSG B
6,631	98	Roofs, HSG B
13,977	98	Paved parking, HSG B
13,315	96	Gravel surface, HSG B
38,881	92	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
6.0					**Direct Entry,**

Subcatchment 2 PRE: Pre 2



Summary for Subcatchment 3 Post: Post 3

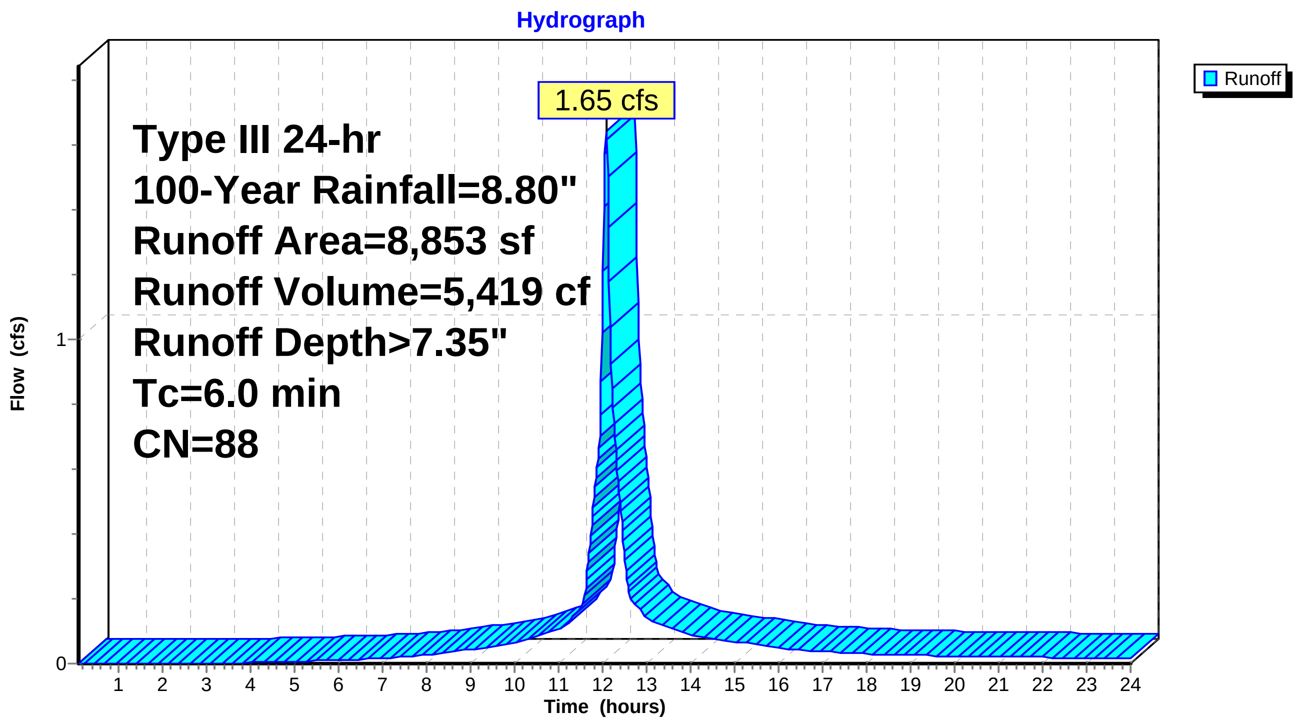
Runoff = 1.65 cfs @ 12.08 hrs, Volume= 5,419 cf, Depth> 7.35"

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 100-Year Rainfall=8.80"

Area (sf)	CN	Description
5,832	96	Gravel surface, HSG B
905	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
8,853	88	Weighted Average
7,948		89.78% Pervious Area
905		10.22% Impervious Area

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

Subcatchment 3 Post: Post 3



Summary for Subcatchment 3 PRE: Pre 3

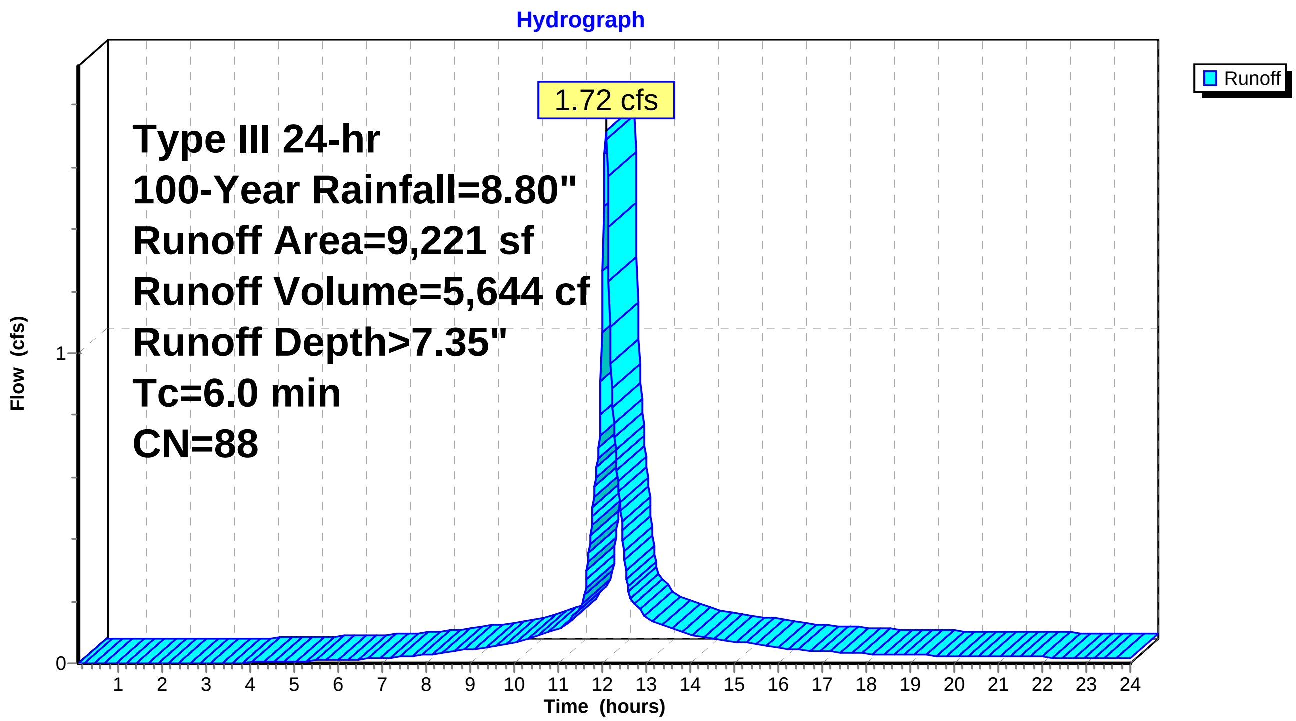
Runoff = 1.72 cfs @ 12.08 hrs, Volume= 5,644 cf, Depth> 7.35"

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 100-Year Rainfall=8.80"

Area (sf)	CN	Description
5,928	96	Gravel surface, HSG B
1,177	98	Paved parking, HSG B
2,116	60	Woods, Fair, HSG B
9,221	88	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
6.0					**Direct Entry,**

Subcatchment 3 PRE: Pre 3



Summary for Subcatchment 4 POST: Post 4

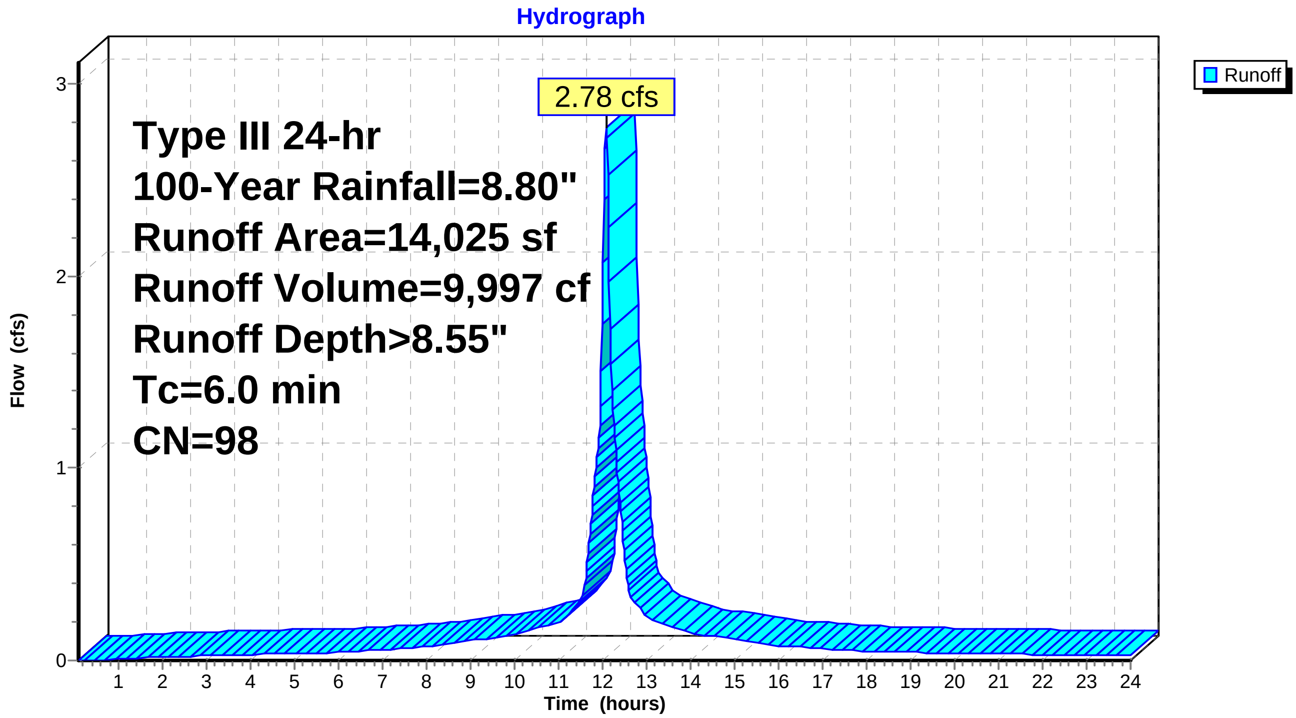
Runoff = 2.78 cfs @ 12.08 hrs, Volume= 9,997 cf, Depth> 8.55"

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=8.80"

Area (sf)	CN	Description
14,025	98	Unconnected roofs, HSG B
14,025		100.00% Impervious Area
14,025		100.00% Unconnected

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

Subcatchment 4 POST: Post 4



Summary for Subcatchment 5 POST: Post 5

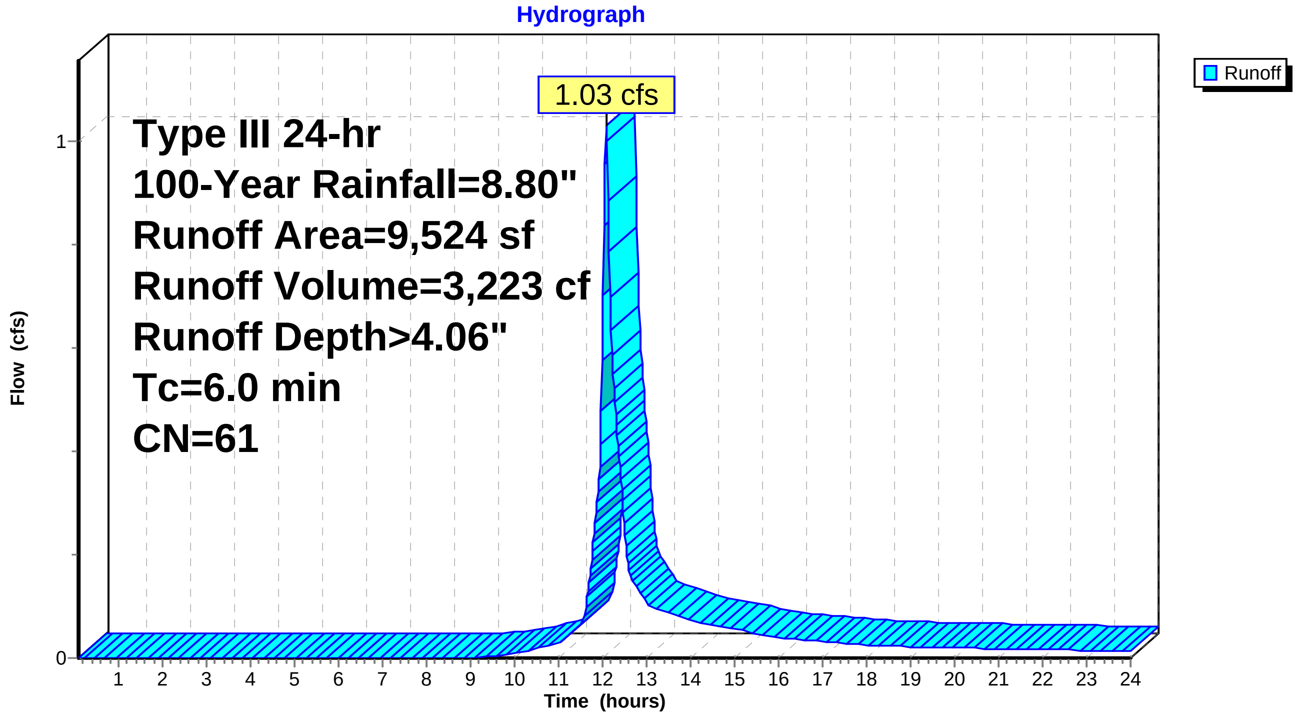
Runoff = 1.03 cfs @ 12.09 hrs, Volume= 3,223 cf, Depth> 4.06"

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=8.80"

Area (sf)	CN	Description
6,804	61	>75% Grass cover, Good, HSG B
2,720	60	Woods, Fair, HSG B
9,524	61	Weighted Average
9,524		100.00% Pervious Area

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

Subcatchment 5 POST: Post 5



Summary for Pond 7R: Subsurface Structure

Inflow Area = 14,025 sf,100.00% Impervious, Inflow Depth > 8.55" for 100-Year event
Inflow = 2.78 cfs @ 12.08 hrs, Volume= 9,997 cf
Outflow = 2.78 cfs @ 12.08 hrs, Volume= 9,348 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.02 cfs @ 1.94 hrs, Volume= 1,370 cf
Primary = 2.76 cfs @ 12.08 hrs, Volume= 7,978 cf

Routing by Stor-Ind method, Time Span= 0.10-24.00 hrs, dt= 0.02 hrs
Peak Elev= 199.53' @ 12.08 hrs Surf.Area= 705 sf Storage= 656 cf

Plug-Flow detention time= 60.4 min calculated for 9,348 cf (94% of inflow)
Center-of-Mass det. time= 24.1 min (763.6 - 739.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	197.70'	425 cf	**3.92'W x 180.00'L x 2.04'H Field A**
			1,440 cf Overall - 377 cf Embedded = 1,063 cf x 40.0% Voids
#2A	198.03'	292 cf	**ADS N-12 12"** x 18 Inside #1
			Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf
			Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf
			18 Chambers in 2 Rows
		717 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	197.70'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	199.50'	**180.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 1.94 hrs HW=197.72' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=2.61 cfs @ 12.08 hrs HW=199.53' (Free Discharge)
└─**2=Sharp-Crested Rectangular Weir** (Weir Controls 2.61 cfs @ 0.54 fps)

Pond 7R: Subsurface Structure - Chamber Wizard Field A

Chamber Model = ADS N-12 12" (ADS N-12® Pipe)
Inside= 12.2"W x 12.2"H => 0.81 sf x 20.00'L = 16.2 cf
Outside= 14.5"W x 14.5"H => 1.05 sf x 20.00'L = 20.9 cf

14.5" Wide + 6.0" Spacing = 20.5" C-C Row Spacing

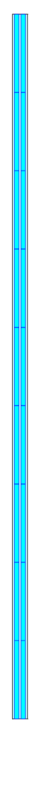
9 Chambers/Row x 20.00' Long = 180.00' Row Length
2 Rows x 14.5" Wide + 6.0" Spacing x 1 + 6.0" Side Stone x 2 = 3.92' Base Width
4.0" Base + 14.5" Chamber Height + 6.0" Cover = 2.04' Field Height

18 Chambers x 16.2 cf = 291.6 cf Chamber Storage
18 Chambers x 20.9 cf = 376.8 cf Displacement

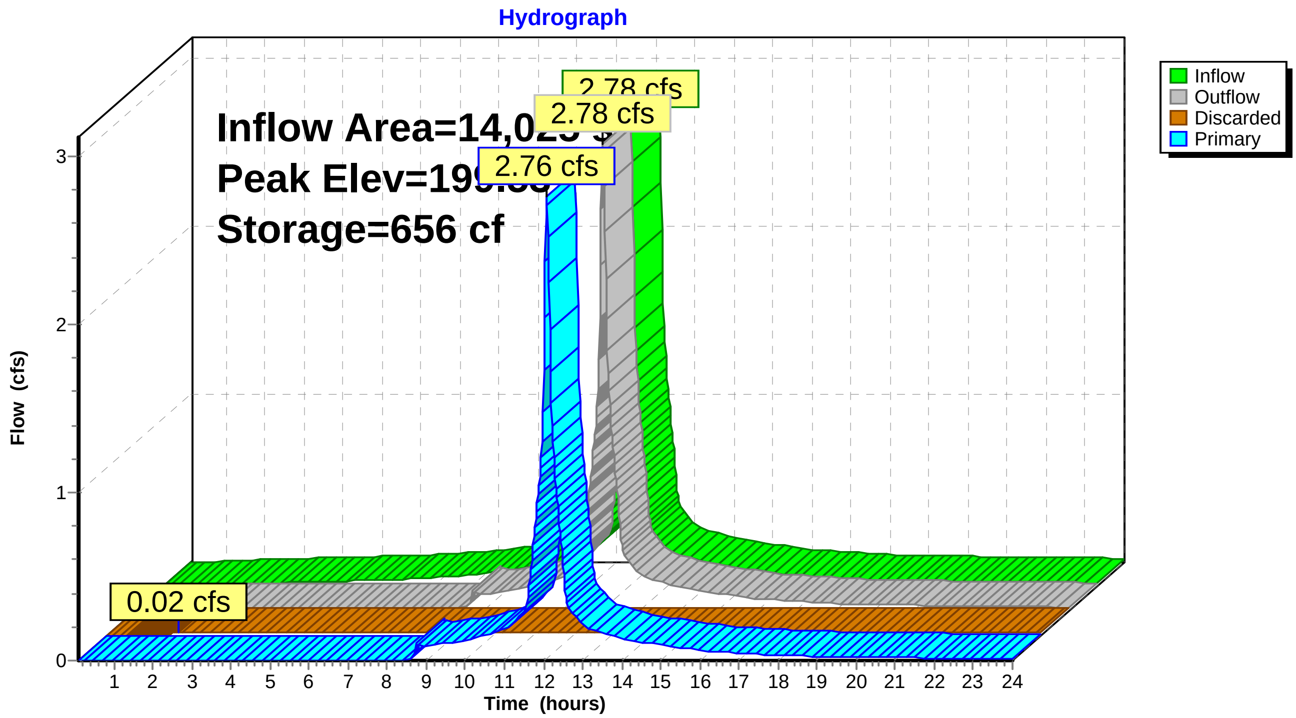
1,440.2 cf Field - 376.8 cf Chambers = 1,063.3 cf Stone x 40.0% Voids = 425.3 cf Stone Storage

Chamber Storage + Stone Storage = 716.9 cf = 0.016 af
Overall Storage Efficiency = 49.8%
Overall System Size = 180.00' x 3.92' x 2.04'

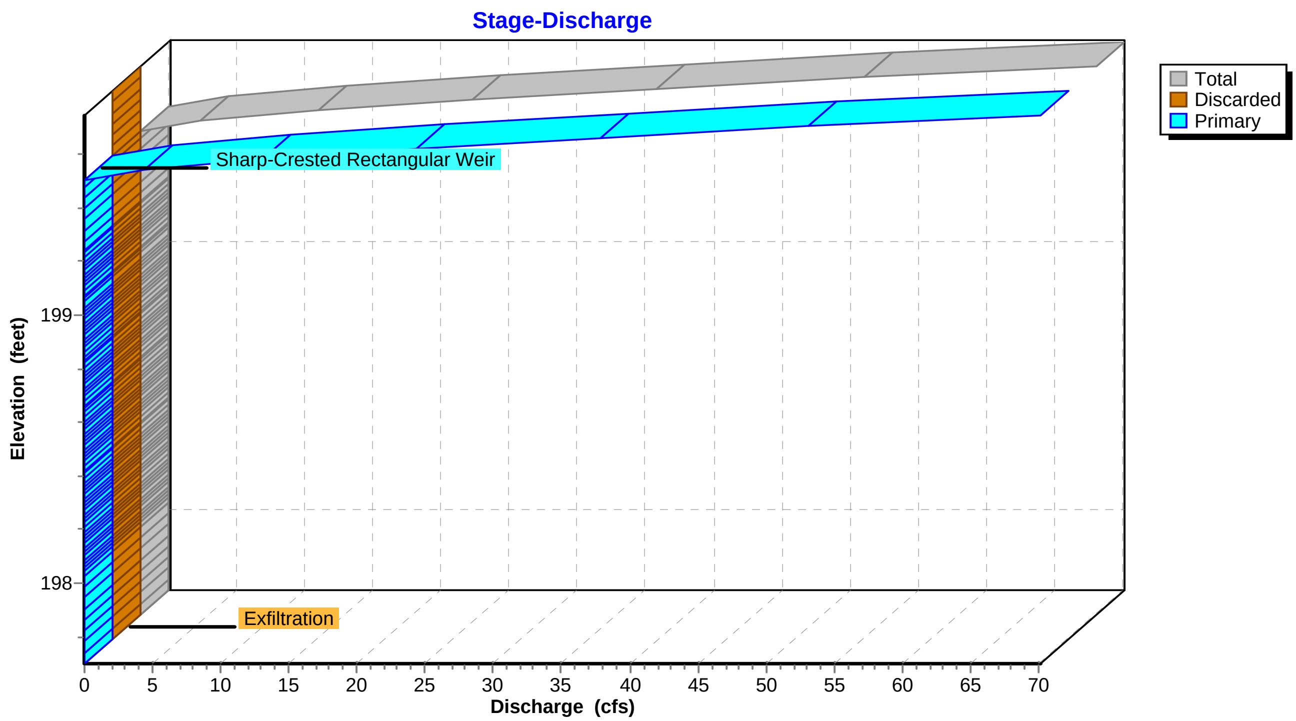
18 Chambers @ $ 0.00 /ea = $ 0.00
53.3 cy Field Excavation @ $ 10.00 /cy = $ 533.39
39.4 cy Stone @ $ 30.00 /cy = $ 1,181.47
Total Cost = $ 1,714.86



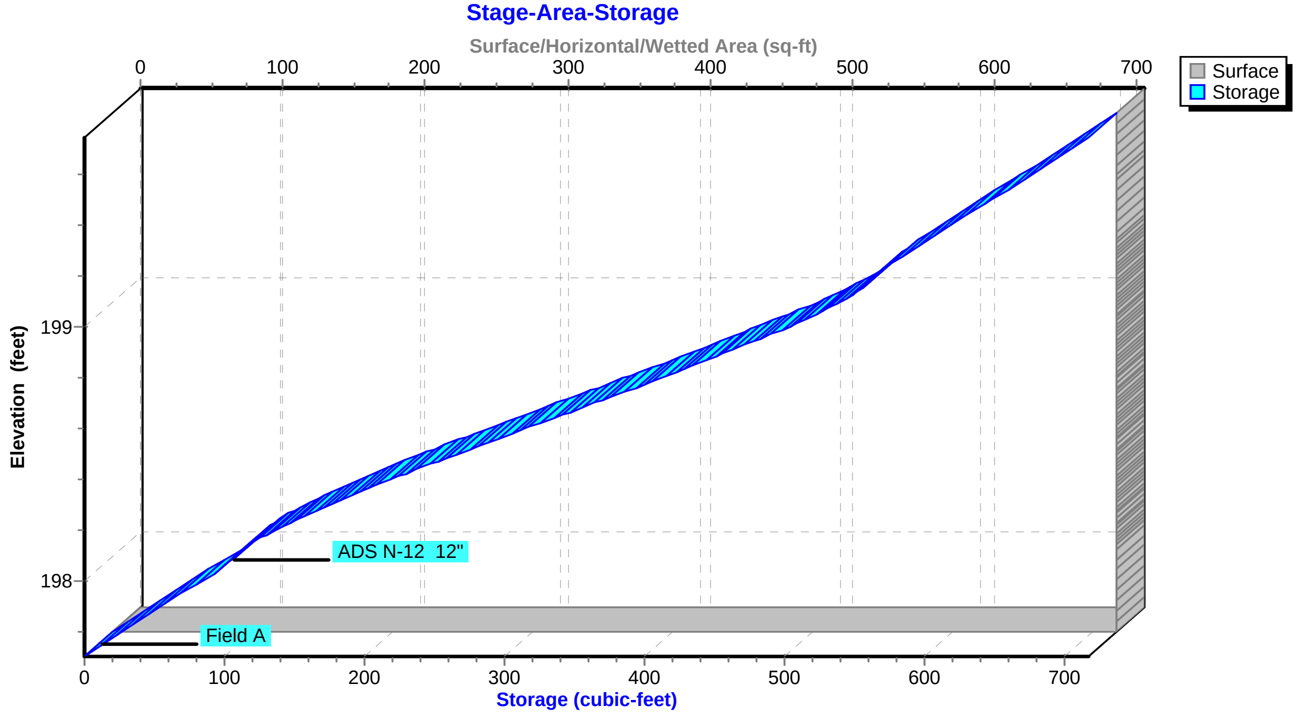
Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure



Pond 7R: Subsurface Structure

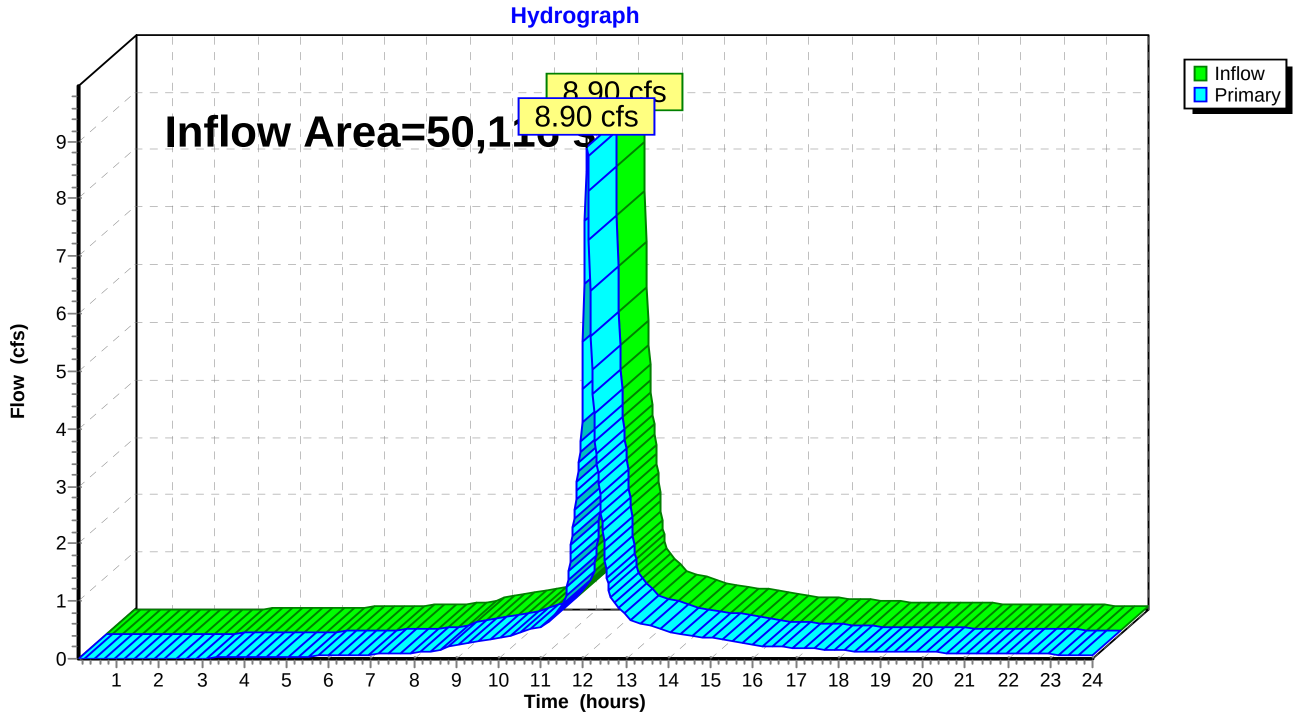


Summary for Link 8L: North West/East Wetland

Inflow Area =	50,116 sf,	43.40% Impervious,	Inflow Depth > 6.83"	for 100-Year event
Inflow =	8.90 cfs @	12.08 hrs, Volume=	28,535 cf	
Primary =	8.90 cfs @	12.08 hrs, Volume=	28,535 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

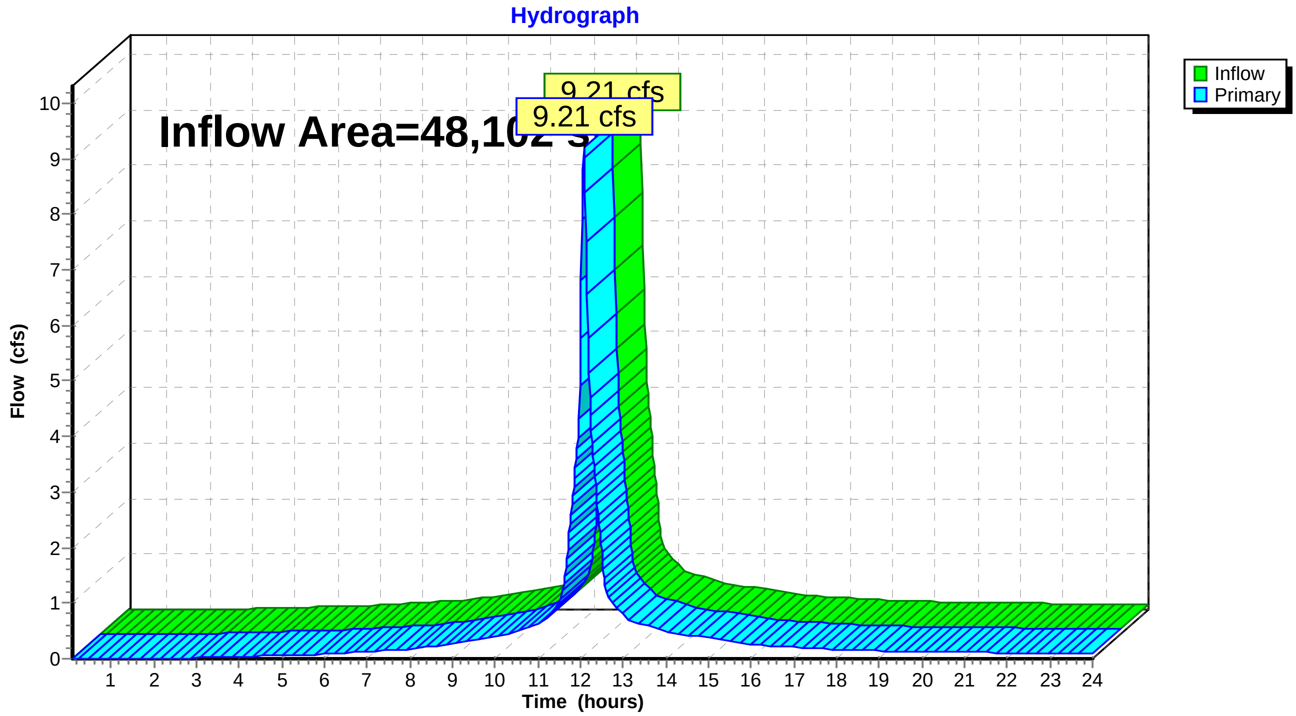


Summary for Link 9L: North West/East Wetland

Inflow Area = 48,102 sf, 45.29% Impervious, Inflow Depth > 7.74" for 100-Year event
Inflow = 9.21 cfs @ 12.08 hrs, Volume= 31,014 cf
Primary = 9.21 cfs @ 12.08 hrs, Volume= 31,014 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

OPERATION AND MAINTENANCE PLAN
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 O
Latest Revision: 6/29/20

Stormwater Control Manager: _____ **Stamp**

Best Management Practice	Inspection Frequency (1)	Date Inspec ted	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 Constructio n 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)

<u>OPERATION AND MAINTENANCE PLAN</u>
PROPOSED DRAINAGE SYSTEM
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:

<u>Subsurface Structures</u>
After construction, the subsurface structures shall be inspected for proper function and stabilization after every major storm event until the lot is completely developed and stabilized. Inspection and routine maintenance of gutters, roof drains is required to prevent sediment from entering the galley system. Inspection shall be done four times per year. If sediment begins to occur within the system perform corrective measures such as vacuum cleaning. Evaluate the system to determine the source of sediment in order to maintain infiltration capacity; as required by the Stormwater Management Policy.

<u>Roof Drains</u>
Gutters shall be inspected and cleaned twice per year of any debris. Roof drain downspouts shall be inspected four times per year for signs of backup and clogging. Roof drain cleanouts shall be inspected and cleaned yearly of any debris.

<u>Lawn Fertilization</u>

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	Four times per year							
Subsurface Structure	Four times 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**

Commonwealth of Massachusetts
Avon, Massachusetts
Soil Suitability Assessment for On-site Sewage Disposal

Performed by: Robert Carlezon
GRADY CONSULTING, L.L.C.
71 Evergreen Street, Suite 1
Kingston, MA 02364
Phone: (781) 585-2300 Fax: (781) 585-2378

Date: 10/8/2020

Witnessed by: N/A

Location Address or Lot #: 540 Bodwell Street Ext

*Owner's Name *Address & *Telephone #: AJM Realty Trust C/O CJ Shaughnessy Crane Service 520 Bodwell Street Ext Avon, MA 02322 781-315-5321

New Construction ___ Repair ___ Title V Inspection ___ Drainage ✓

Office Review
Published Soil Survey Available: No ✓ Yes___
Year Published: _________ Publication Scale: _____________ Soil Map Unit: ___________
Drainage Class: _________ Soil Limitations: ______________________________

Surficial Geology Report Available: No ✓ Yes ___
Year Published: _________ Publication Scale: ______________
Geologic Material (Map Unit): ______________________________
Landform: ____

Flood Insurance Rate Map:
Above 500 year flood boundary: **No** ____ **Yes** ✓
Within 500 year flood boundary **No** ✓ **Yes** ____
Within 100 year flood boundary **No** ✓ **Yes** ____

Wetland Area:
National Wetland Inventory Map (map unit): On-site Delineation
Wetlands Conservancy Program Map (map unit): ______________________

Current Water Resource Conditions (USGS): **Month:** * October
Range: **Above Normal** ______ **Normal** ______ **Below Normal** ✓

Other References Reviewed: * USGS Real Time Data – Norfolk #27

Depth of Naturally Occurring Pervious Material
Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system?
N/A Groundwater Determination Only / (Drainage testholes)
If not, what is the depth of naturally occurring pervious material?

Certification
I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise, and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated on the attached soil evaluation form, are accurate and in accordance with CMR 15.100 through 15.107.

Signature: [signature] Date: 10/8/2020

TITLE 5 ON-SITE REVIEW

Deep Hole # D-1 **Date** 10/8/2020 **Time** 9:30 **Weather** Sunny 65°
Location(identify on Site Plan)______
Land Use Commercial/Industrial **Slope(%)** 0-3 **Surface Stones** NONE
Vegetation Gravel, Deciduous **Landform**______

Distances from: Open Water Body >400 ft. Possible Wet Area 45± ft. Drinking Water Well >100 ft.

Drainageway 50± ft. Propertyline 50± ft Other______

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"-10"	Fill				
10"-36"	C	Sandy Loam	5Y 5/3	32"	Friable Firm in Place, 10% gravel, 10% cobbles, few boulders

Depth= 3'-6"

No Weeping, Mottling @ 2'-8" (Faint Mottling)

Parent Material (geologic) Glacial Till **Depth to Bedrock** N/A
Depth to Groundwater: **Standing Water in Hole:** NONE **Weeping from Pit Face** N/A
Estimated Seasonal High Groundwater 32"

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:
___ **Depth observed standing in observation hole:** ____**inches** ____**Depth to soil mottles:** N/A **inches**
___ **Depth to weeping from side of observation hole:**____**inches** ____ **Groundwater adjustment**____**ft**
Index Well #____ **Reading Date**____ **Index well level**____ **Adj.factor**____ **Adj.Groundwater level**____

PERCOLATION TEST **Date**______ **Time**______

Observation Hole #			**Time at 9"**		
Depth of Perc			**Time at 6"**		
Start Presoak			**Time (9"-6")**		
End Presoak			**Rate Min/Inch**		

Site Suitability Assessment: **Site Passed**____ **Site Failed**____ **Additional Testing Needed:**
Performed By Rob Carleton **Certification #**______
Witnessed By N/A
Comments:

TITLE 5 ON-SITE REVIEW

Deep Hole # D-2 **Date** 10/8/2020 **Time** 11:30 **Weather** Sunny 65°
Location(identify on Site Plan) ______
Land Use Commercial/Industrial **Slope(%)** 3-8 **Surface Stones** Yes
Vegetation Pine/Deciduous mix **Landform** ______

Distances from: Open Water Body >400 ft. Possible Wet Area 10± ft. Drinking Water Well >100 ft.

Drainageway 20± ft. Propertyline 20± ft Other ______

DEEP OBSERVATION HOLE LOG

Depth From Surface (Inches)	Soil Horizon (USDA	Soil Texture (Munsell)	Soil Color	Soil Mottling	Other: Structures, Stones, Boulders, Consistency,%Gravel
0"-6"	A	Sandy Loam	10YR 3/2		
6"-30"	B	Sandy Loam	10YR 5/4	30"	Friable, Massive
30"-46"	C	Sandy Loam	2.5Y 5/2		Several large boulders, 5% cobbles Friable, Massive, 5% gravel

Depth= 3'-10"

Mottling @ 2'-6" No Weeping

Parent Material (geologic) Glacial Till **Depth to Bedrock** N/A
Depth to Groundwater: **Standing Water in Hole:** NONE **Weeping from Pit Face** NONE
Estimated Seasonal High Groundwater 30"

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method Used:
___ **Depth observed standing in observation hole:** ____ **inches** ____ **Depth to soil mottles:** 30" **inches**
___ **Depth to weeping from side of observation hole:** ____ **inches** ____ **Groundwater adjustment** ____ **ft**
Index Well # ____ **Reading Date** ____ **Index well level** ____ **Adj.factor** ____ **Adj.Groundwater level** ____

PERCOLATION TEST **Date** ______ **Time** ______

Observation Hole # ______ ______ **Time at 9"** ______ ______
Depth of Perc ______ ______ **Time at 6"** ______ ______
Start Presoak ______ ______ **Time (9"-6")** ______ ______
End Presoak ______ ______ **Rate Min/Inch** ______ ______

Site Suitability Assessment: **Site Passed** ____ **Site Failed** ____ **Additional Testing Needed:**
Performed By Rob Carlezon **Certification #** ______
Witnessed By N/A
Comments:

Hydrologic Soil Group—Norfolk and Suffolk Counties, Massachusetts
(540 Bodwell Street)

Map Scale: 1:1,600 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 20 40 80 120

Feet: 0 50 100 200 300

N

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 Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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 16, Jun 11, 2020

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.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
51	Swansea muck, 0 to 1 percent slopes	B/D	0.1	1.0%
424B	Canton fine sandy loam, 3 to 8 percent slopes, extremely bouldery	A	1.1	9.1%
602	Urban land, 0 to 15 percent slopes		2.6	21.7%
603	Urban land, wet substratum, 0 to 3 percent slopes		7.6	63.8%
652	Udorthents, refuse substratum	A	0.1	0.6%
654	Udorthents, loamy	A	0.5	3.9%
Totals for Area of Interest			**11.9**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Vegetated Filter Strips

Description: Vegetated filter strips, also known as filter strips, grass buffer strips and grass filters, are uniformly graded vegetated surfaces (i.e., grass or close-growing native vegetation) that receive runoff from adjacent impervious areas. Vegetated filter strips typically treat sheet flow or small concentrated flows that can be distributed along the width of the strip using a level spreader. Vegetated filter strips are designed to slow runoff velocities, trap sediment, and promote infiltration, thereby reducing runoff volumes.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	Provides some peak flow attenuation but usually not enough to achieve compliance with Standard 2
3 - Recharge	No recharge credit
4 - TSS Removal	If greater than or equal to 25' and less than 50' wide, 10% TSS removal. If greater than or equal to 50' wide, 45% TSS removal.
5 - Higher Pollutant Loading	May be used as part of a pretreatment train if lined
6 - Discharges near or to Critical Areas	May be used as part of a pretreatment train if lined. May be used near cold-water fisheries.
7 - Redevelopment	Suitable for pretreatment or as a stand-alone practice if sufficient land is available.

Advantages/Benefits:

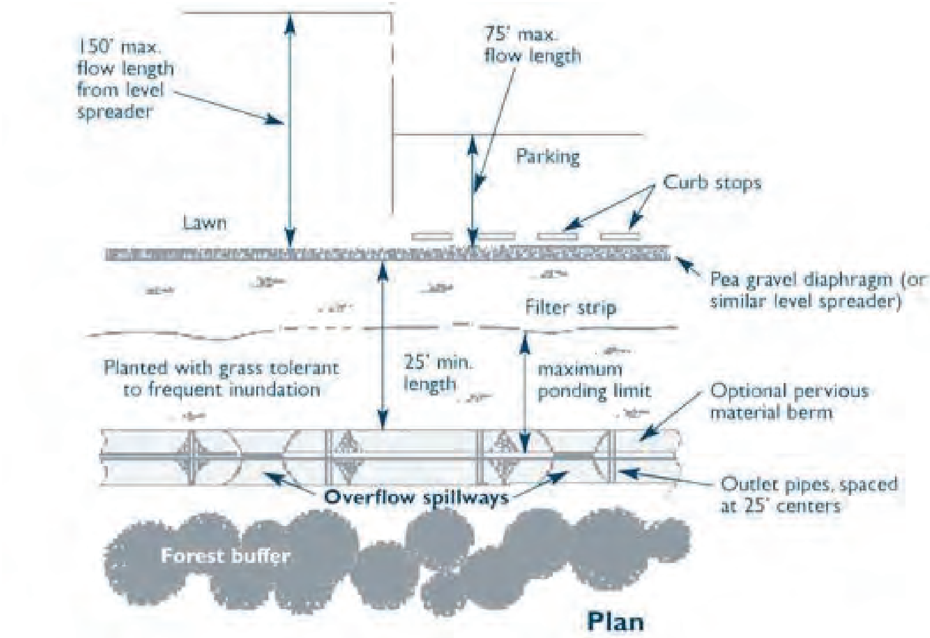
- Reduces runoff volumes and peak flows.
- Slows runoff velocities and removes sediment.
- Low maintenance requirements.
- Serves as an effective pretreatment for bioretention cells
- Can mimic natural hydrology
- Small filter strips may be used in certain urban settings.
- Ideal for residential settings and to treat runoff from small parking lots and roads.
- Can be used as part of runoff conveyance system in combination with other BMPs
- Little or no entrapment hazard for amphibians or other small creatures

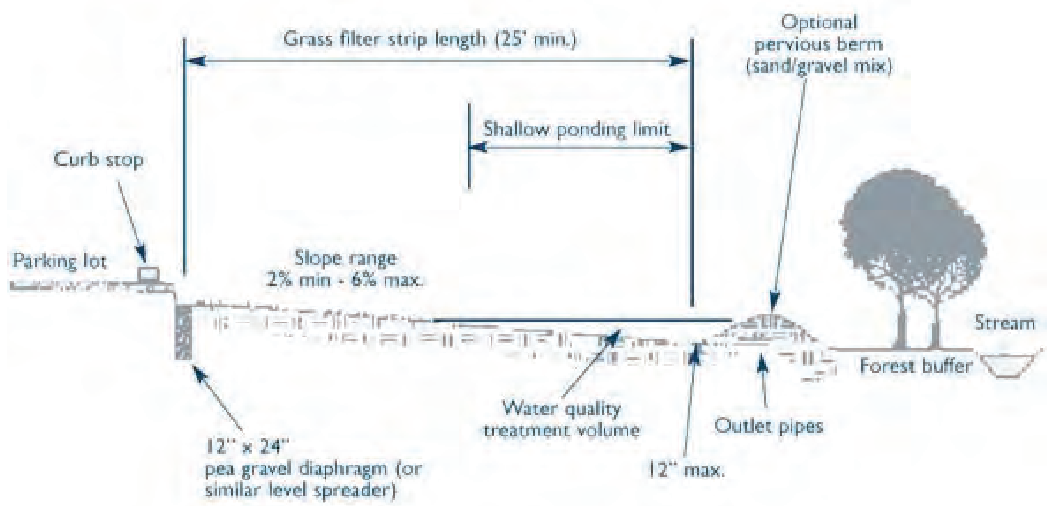
Disadvantages/Limitations:

- Variability in removal efficiencies, depending on design
- Little or no treatment is provided if the filter strip is short-circuited by concentrated flows.
- Often a poor retrofit option due to large land requirements.
- Effective only on drainage areas with gentle slopes (less than 6 percent).
- Improper grading can greatly diminish pollutant removal.

Pollutant Removal Efficiencies

- TSS (if filter strip is 25 feet wide) — 10% assumed (Regulatory)
- TSS (if filter strip is 50 feet wide) — 45% assumed (Regulatory)
- Nutrients (Nitrogen, phosphorus) — Insufficient data
- Metals (copper, lead, zinc, cadmium) — Insufficient data
- Pathogens (coliform, e coli) — Insufficient data





adapted from the "Design of Stormwater Systems" 1996

Maintenance

Activity	Frequency
Inspect the level spreader for sediment buildup and the vegetation for signs of erosion, bare spots, and overall health.	Every six months during the first year. Annually thereafter.
Regularly mow the grass.	As needed
Remove sediment from the toe of slope or level spreader and reseed bare spots.	As needed

Special Features

Include an impermeable liner and underdrain for discharges from Land Use with Higher Potential Pollutant Loads and for discharges within Zone IIs and Interim Wellhead Protection Areas; for discharges near or to other critical areas or in soils with rapid infiltration rates greater than 2.4 inches per hour.

Vegetated Filter Strips

Applicability

Vegetated filter strips are used to pretreat sheet flow from roads, highways, and small parking lots. In residential settings, they are useful in pretreating sheet flow from driveways. They provide effective pretreatment, especially when combined with bioretention areas and stream buffers. Urban areas can sometimes accommodate small filter strips depending on available land area, making them potential retrofit options in certain urban settings. Vegetated filter strips can also be used as side slopes of grass channels or water quality swales to enhance infiltration and remove sediment.

Effectiveness

Variable TSS removal efficiencies have been reported for filter strips, depending on the size of the contributing drainage area, the width of the filter strip, the underlying parent soil, the land slope, the type of vegetation, how well the vegetation is established, and maintenance practices. Vegetated filter strips may remove nutrients and metals depending on the length and slope of the filter, soil permeability, size and characteristics of the drainage area, type of vegetative cover, and runoff velocity.

Planning Considerations

Vegetated filter strips may be used as a stand-alone practice for redevelopments, only where other practices are not feasible. Vegetated filter strips can be designed to fit within the open space and rights of way that are available along roads and highways. Do not design vegetated filter strips to accept runoff from land uses with higher potential pollutant loads (LUHHPL) without a liner. Vegetated filter strips function best for drainage areas of one acre or less with gentle slopes.

Design

Do not locate vegetated filter strips in soils with high clay content that have limited infiltration or in soils that cannot sustain grass cover.

The filter strip cannot extend more than 50 feet into a Buffer Zone to a wetland resource area.

The contributing drainage area to a vegetated filter strip is limited to one acre of less.

Design vegetated filter strips with slopes between 2 and 6 percent. Steeper slopes tend to create concentrated flows. Flatter slopes can cause ponding and create mosquito-breeding habitat.

Design the top and toe of the slope to be as flat as possible. Use a level spreader at the top of the slope to evenly distribute overland flows or concentrated runoff across the entire length of the filter strip. Many variations of level spreader designs may be used including level trenches, curbing and concrete weirs. The key to any level spreader design is creating a continuous overflow elevation along the entire width of the filter strip.

Velocity dissipation (e.g. by using riprap) may be required for concentrated flows.

Design the filter strip to drain within 24 hours after a storm. The design flow depth must not exceed 0.5 inches.

To recieve TSS removal credit, make the filter strip at least 25 feet long and generally as wide as the area draining to the strip. To prevent high-velocity concentrated flows, the length of the flow path must be limited to 75 feet if the filter strip handles runoff from impervious surfaces, and 150 feet if the filter strip handles runoff from pervious surfaces. The minimum width of the filter strip must be 20% of the length of the flow path or 8 feet, whichever is greater.

To prevent groundwater contamination, the filter strip must be constructed at least 2 feet above seasonal high groundwater and 2 to 4 feet above bedrock.

The filter strip must be planted with grasses that are relatively salt-tolerant. Select grasses to withstand high flow velocities under wet weather conditions.

A vegetated filter strip may be used as a qualifying pervious area for purposes of the LID Site Design Credits for disconnecting rooftop and nonroof top runoff.

Construction

Proper grading is essential to establish sheet flow from the level spreader and throughout the filter strip.

Implement soil stabilization measures until permanent vegetation is established.

Protect the area to be used for the filter strip by using upstream sediment traps.

Use as much of the existing topsoil on the site as possible to enhance plant growth.

Maintenance

Regular maintenance is critical for filter strips to be effective and to ensure that flow does not short-circuit the system. Conduct semi-annual inspections during the first year (and annually thereafter). Inspect the level spreader for sediment buildup and the vegetation for signs of erosion, bare spots, and overall health. Regular, frequent mowing of the grass is required. Remove sediment from the toe of slope or level spreader, and reseed bare spots as necessary. Periodically, remove sediment that accumulates near the top of the strip to maintain the appropriate slope and prevent formation of a "berm" that could impede the distribution of runoff as sheet flow.

When the filter strip is located in the buffer zone to a wetland resource area, the operation and maintenance plan must include strict measures to ensure that maintenance operations do not alter the wetland resource areas. Please note, filter strips are restricted to the outer 50 feet of the buffer zone.

Cold Climate Considerations

In cold climates such as Massachusetts, the depth of soil media that serves as the planting bed must extend below the frost line to minimize the effects of freezing. Avoid using peat and compost media, which retain water and freeze during the winter, and become impermeable and ineffective.

References:

Center for Watershed Protection, Stormwater Management Fact Sheet: Grassed Filter Strip, http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Filtering%20Practice/Grassed%20Filter%20Strip.htm

Claytor, R.A. and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Silver Spring, Maryland.

Connecticut Department of Environmental Protection. 2004. Connecticut Stormwater Quality Manual.

International Stormwater BMP Database, Biofilter – Grass Strip, http://www.bmpdatabase.org

Knox County, Stormwater Management Manual, Volume 2, Section 4.3.9, Filter Strip, Pp. 4-155 to 4-164, http://knoxcounty.org/stormwater/pdfs/vol2/4-3-9%20Filter%20Strip.pdf

Knoxville, City of, 2003, Knoxville BMP Manual Stormwater Treatment, Filter Strips and Swales, Practice No. ST – 05, http://www.ci.knoxville.tn.us/engineering/bmp_manual/ST-05.pdf

Maine Department of Environmental Protection. 2006, Maine Stormwater Best Management Practices Manual, Chapter 5, Pp. 5-1 to 5-18, http://www.maine.gov/dep/blwq//docstand/stormwater/stormwaterbmps/vol3/chapter5.pdf

Maryland Department of the Environment, 2000, Maryland Stormwater Design Manual, Volume I, Chapter 2, Unified Sizing Criteria, P. 2.39, http://www.mde.state.md.us/assets/document/chapter2.pdf

Massachusetts Highway Department. 2004. Storm Water Handbook for Highways and Bridges.

Metropolitan Council. 2001. Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates. Prepared by Barr Engineering Company. St. Paul, Minnesota.

New Jersey Department of Environmental Protection, 2004, Best Management Practice Manual, Chapter 9.10, Standard for Vegetated Filter Strip, Pp. 9.10-1 to 9.11-10, http://www.njstormwater.org/tier_A/pdf/NJ_SWBMP_9.10.pdf

New York State Department of Environmental Conservation (NYDEC). 2001. New York State Stormwater Management Design Manual. Prepared by Center for Watershed Protection. Albany, New York.

United States Environmental Protection Agency (EPA). 1999. Preliminary Data Summary of Urban Storm Water Best Management Practices. EPA 821-R99-012.

United States Environmental Protection Agency (EPA). 2002. National Menu of Best Management Practices for Stormwater Phase II. URL: http://www.epa.gov/npdes/menuofbmps/menu.htm, Last Modified January 24, 2002.

Virginia Department of Conservation and Recreation, Chapter 3, Minimum Standard 3.14, Vegetated Filter Strip, Pp. 3.14-1 to 3.14.-14, http://dcr.state.va.us/soil_&_water/documents/Chapter_3-14.pdf

Yu, S.L., S.L. Barnes, and V.W. Gerde, 993. Testing of Best Management Practices for Controlling Highway Runoff. Virginia Transportation Research Council, Charlottesville, VA.

Subsurface Structures

Description: Subsurface structures are underground systems that capture runoff, and gradually infiltrate it into the groundwater through rock and gravel. There are a number of underground infiltration systems that can be installed to enhance groundwater recharge. The most common types include pre-cast concrete or plastic pits, chambers (manufactured pipes), perforated pipes, and galleys.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	Provides groundwater recharge
4 - TSS Removal	80%
5 - Higher Pollutant Loading	May be used if 44% of TSS is removed with a pretreatment BMP prior to infiltration. Land uses with the potential to generate runoff with high concentrations of oil and grease require an oil grit separator or equivalent prior to discharge to the infiltration structure. Infiltration must be done in accordance with 314 CMR 5.00.
6 - Discharges near or to Critical Areas	Highly recommended
7 - Redevelopment	Suitable with pretreatment

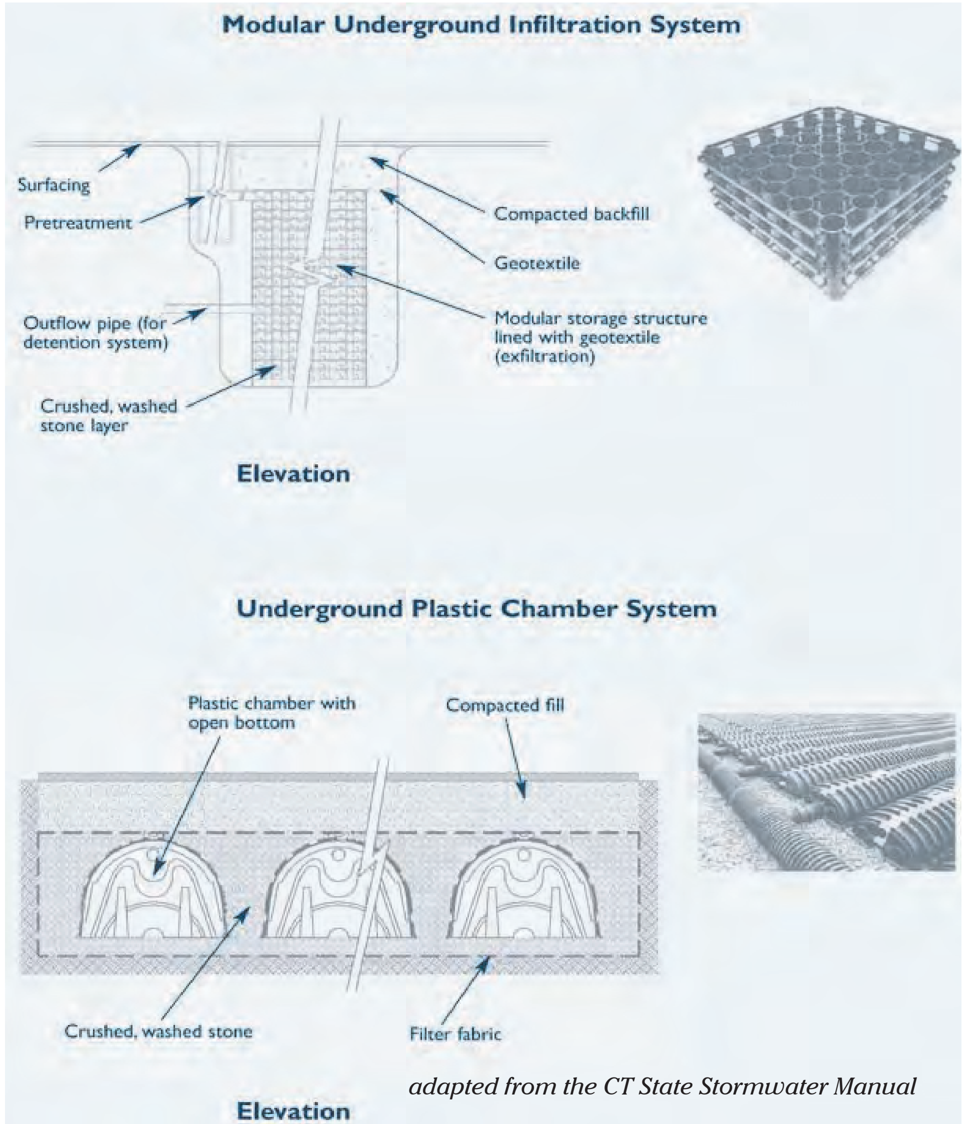
Advantages/Benefits:
- Provides groundwater recharge
- Reduces downstream flooding
- Preserves the natural water balance of the site
- Can remove other pollutants besides TSS
- Can be installed on properties with limited space
- Useful in stormwater retrofit applications

Disadvantages/Limitations:
- Limited data on field performance
- Susceptible to clogging by sediment
- Potential for mosquito breeding due to standing water if system fails

Pollutant Removal Efficiencies

• Total Suspended Solids (TSS)	80%
• Nutrients (Nitrogen, phosphorus)	Insufficient data
• Metals (copper, lead, zinc, cadmium)	Insufficient data
• Pathogens (coliform, e coli)	Insufficient data

Subsurface Structures



adapted from the CT State Stormwater Manual

There are different types of subsurface structures:

Infiltration Pit: A pre-cast concrete or plastic barrel with uniform perforations. The bottom of the pit should be closed with the lowest row of perforations at least 6 inches above the bottom, to serve as a sump. Infiltration pits typically include an observation well. The pits may be placed linearly, so that as the infiltrative surfaces in the first pit clog, the overflow moves to the second pit for exfiltration. Place an outlet near the top of the infiltration pit to accommodate emergency overflows. MassDEP provides recharge credit for storage below the emergency outflow invert. To make an infiltration pit, excavate the pit, wrap fabric around the barrel, place stone in the bottom of the pit, place the barrel in the pit, and then backfill stone around the barrel. Take a boring or dig an observation trench at the site of each proposed pit.

Chambers: These are typically manufactured pipes containing open bottoms and sometimes perforations. The chambers are placed atop a stone bed. Take the same number of borings or observation pits as for infiltration trenches. Do not confuse these systems with underground detention systems (UDS) that use similar chambers. UDS are designed to attenuate peak rates of runoff--not to recharge groundwater.

Perforated Pipes: In this system, pipes containing perforations are placed in a leaching bed, similar to a Title 5 soil absorption system (SAS). The pipes dose the leaching bed. Take the same number of borings or observation pits as for infiltration trenches. Perforated pipes by themselves do not constitute a stormwater recharge system and receive no credit pursuant to Stormwater Standard No. 3. Do not confuse recharge systems that use perforated pipes with perforated pipes installed to lower the water table or divert groundwater flows.

Galleys: Similar to infiltration pits. Some designs consist of concrete perforated rectangular vaults. Others are modular systems usually placed under parking lots. When the galley design consists of a single rectangular perforated vault, conduct one boring or observation trench per galley. When the galleys consist of interlocking modular units, take the same number of borings or observation pits as for infiltration trenches. Do not confuse these galleys with vaults storing water for purposes of underground detention, which do not contain perforations.

Applicability

Subsurface structures are constructed to store stormwater temporarily and let it percolate into the underlying soil. These structures are used for small drainage areas (typically less than 2 acres). They are feasible only where the soil is adequately permeable and the maximum water table and/or bedrock elevation is sufficiently low. They can be used to control the quantity as well as quality of stormwater runoff, if properly designed and constructed. The structures serve as storage chambers for captured stormwater, while the soil matrix provides treatment.

Without adequate pretreatment, subsurface structures are not suitable for stormwater runoff from land uses or activities with the potential for high sediment or pollutant loads. Structural pretreatment BMPs for these systems include, but are not limited to, deep sump catch basins, proprietary separators, and oil/grit separators. They are suitable alternatives to traditional infiltration trenches and basins for space-limited sites. These systems can be installed beneath parking lots and other developed areas provided the systems can be accessed for routine maintenance.

Subsurface systems are highly prone to clogging. Pretreatment is always required unless the runoff is strictly from residential rooftops.

Effectiveness

Performance of subsurface systems varies by manufacturer and system design. Although there are limited field performance data, pollutant removal efficiency is expected to be similar to those of infiltration trenches and basins (i.e., up to 80% of TSS removal). MassDEP awards a TSS removal credit of 80% for systems designed in accordance with the specifications in this handbook.

Planning Considerations

Subsurface structures are excellent groundwater recharge alternatives where space is limited. Because infiltration systems discharge runoff to groundwater, they are inappropriate for use in areas with potentially higher pollutant loads (such as gas stations), unless adequate pretreatment is provided. In that event, oil grit separators, sand filters or equivalent BMPs must be used to remove sediment, floatables and grease prior to discharge to the subsurface structure.

Design

Unlike infiltration basins, widely accepted design standards and procedures for designing subsurface structures are not available. Generally, a subsurface structure is designed to store a "capture volume" of runoff for a specified period of "storage time." The definition of capture volume differs depending on the purpose of the subsurface structure and the stormwater management program being used. Subsurface structures should infiltrate good quality runoff only. Pretreatment prior to infiltration is essential.
The composition, configuration and layout of subsurface structures varies considerably depending on the manufacturer. Follow the design criteria specified by vendors or system manufacturers. Install subsurface structures in areas that are easily accessible for routine and non-routine maintenance.

As with infiltration trenches and basins, install subsurface structures only in soils having suitable infiltration capacities as determined through field testing. Determine the infiltrative capacity of the underlying native soil through the soil evaluation set forth in Volume 3. Never use a standard septic system percolation test to determine soil permeability because this test tends to greatly overestimate the infiltration capacity of soils.

Subsurface structures are typically designed to function off-line. Place a flow bypass structure upgradient of the infiltration structure to convey high flows around the structure during large storms.

Design the subsurface structure so that it drains within 72 hours after the storm event and completely dewaters between storms. Use a minimum draining time of 6 hours to ensure adequate pollutant removal. Design all ports to be mosquito-proof, i.e., to inhibit or reduce the number of mosquitoes able to breed within the BMP.

The minimum acceptable field infiltration rate is 0.17 inches per hour. Subsurface structures must be sized in accordance with the procedures set forth in Volume 3. Manufactured structures must also be sized in accordance with the manufacturers' specifications. Design the system to totally exfiltrate within 72 hours.

Design the subsurface structure for live and dead loads appropriate for their location. Provide measures to dissipate inlet flow velocities and prevent channeling of the stone media. Generally, design the system so that inflow velocities are less than 2 feet per second (fps).
All of these devices must have an appropriate number of observation wells, to monitor the water surface elevation within the well, and to serve as a sampling port.

Each of these different types of structures, with the exception of perforated pipes in leaching fields similar to Title 5 systems, must have entry ports to allow worker access for maintenance, in accordance with OSHA requirements.

Construction

Stabilize the site prior to installing the subsurface structure. Do not allow runoff from any disturbed areas on the site to flow to the structure. Rope off the area where the subsurface structures are to be placed. Accomplish any required excavation with equipment placed just outside of this area. If the size of the area intended for exfiltration is too large to accommodate this approach, use trucks with low-pressure tires to minimize compaction. Do not allow any other vehicles within the area to be excavated. Keep the area above and immediately surrounding the subsurface structure roped off to all construction vehicles until the final top surface is installed (either paving or landscaping). This prevents additional compaction. When installing the final top surface, work from the edges to minimize compaction of the underlying soils.

Before installing the top surface, implement erosion and sediment controls to prevent sheet flow or wind blown sediment from entering the leach field. This includes, but is not limited to, minimizing land disturbances at any one time, placing stockpiles away from the area intended for infiltration, stabilizing any stockpiles through use of vegetation or tarps, and placing sediment fences around the perimeter of the infiltration field.

Provide an access port, man-way, and observation well to enable inspection of water levels within the system. Make the observation well pipe visible at grade (i.e., not buried).

Maintenance

Because subsurface structures are installed underground, they are extremely difficult to maintain. Inspect inlets at least twice a year. Remove any debris that might clog the system. Include mosquito controls in the Operation and Maintenance Plan.

Adapted from:
Connecticut Department of Environmental Conservation. Connecticut Stormwater Quality Manual. 2004.
MassHighway. Storm Water Handbook for Highways and Bridges. May 2004.

BMP Accessories: Level Spreaders, Check Dams, Outlet Structures, Catch Basin Inserts

BMP accessories are not BMPs themselves but are required to facilitate the operation and function of BMPs. This section presents four of the most common and important BMP accessories: level spreaders, check dams, outlet structures, and catch basin inserts.

Level Spreaders

Description

A level spreader receives concentrated flow from channels, outlet structures, or other conveyance structures, and converts it to sheet flow where it can disperse uniformly across a stable slope. A level spreader is not a pollutant reduction device. It improves the efficiency of other BMPs, such as vegetated swales, filter strips, or infiltration systems that depend on sheet flow to operate properly.

Applicability and Planning Considerations

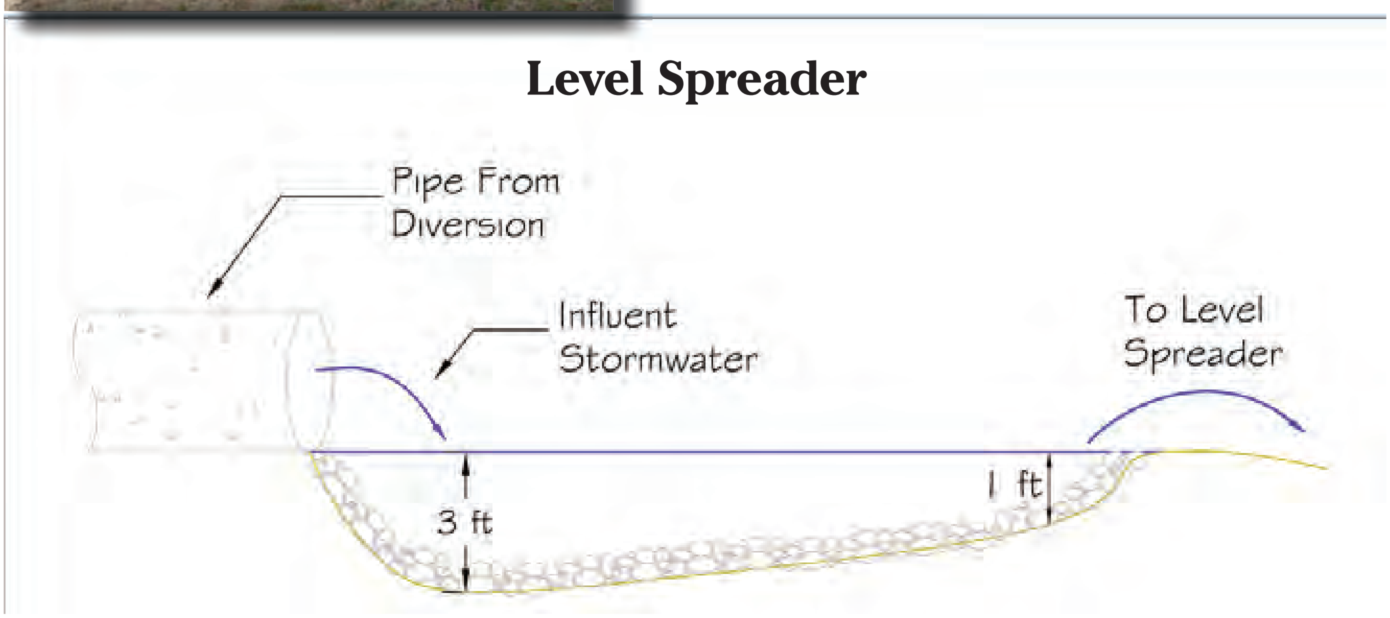
Level spreaders are used in wide, level areas where concentrated runoff occurs. They should be placed on undisturbed soil that has been stabilized with vegetation. Disturbed soils are more erodible. If the spreader is not absolutely level, flow will concentrate at the low point and may worsen erosion problems. Flows to the level spreader should be relatively free of sediment, or the level spreader could be quickly overwhelmed by sediment and lose its effectiveness.

Design and Construction

Level spreaders are usually made of rocks, lumber, or concrete. Typical depths of flow behind each spreader range from 6 to 12 inches.

Construct level spreaders to be absolutely level. Small variations in height of even 0.25 inches can cause water to quickly concentrate and create erosion problems. A 4-inch variation in ground elevation across the entire length of the level spreader can make level construction difficult.

The height of the spreader is based on design flow, allowing for sediment and debris deposition. Design the length of the spreader based on the 10-year design flow for the site or the sheet flow path width, whichever is greater. When designing for the 10-year design flow, use the following table:



adapted from the North Carolina State University

Drainage Area	Minimum spreader length
1 acre	10 feet
2 acres	10 feet
3 acres	15 feet
4 acres	18 feet
5 acres	20 feet

The slope leading to the level spreader should be less than 1% for at least 20 feet immediately upstream, to keep runoff velocities less than 2 feet per second during the 10-year storm event. The slope at the outlet of the spreader should be 6% or less.

Maintenance

Inspect level spreaders regularly, especially after large rainfall events. Note and repair any erosion or low spots in the spreader.

Adapted from:
Idaho Department of Environmental Quality. Catalog of Stormwater BMPs for Cities and Counties, 209-210.
MassDEP, Massachusetts Nonpoint Source Pollution Management Manual, 2006.
http://www.mass.gov/dep/water/laws/policies.htm#storm
Additional Resources:
Hunt, W.F. et al. Designing Level Spreaders to Treat Stormwater Runoff. North Carolina State University, as presented at North Carolina Department of Transportation Level Spreader Workshop, February 19, 2001, Raleigh, NC.

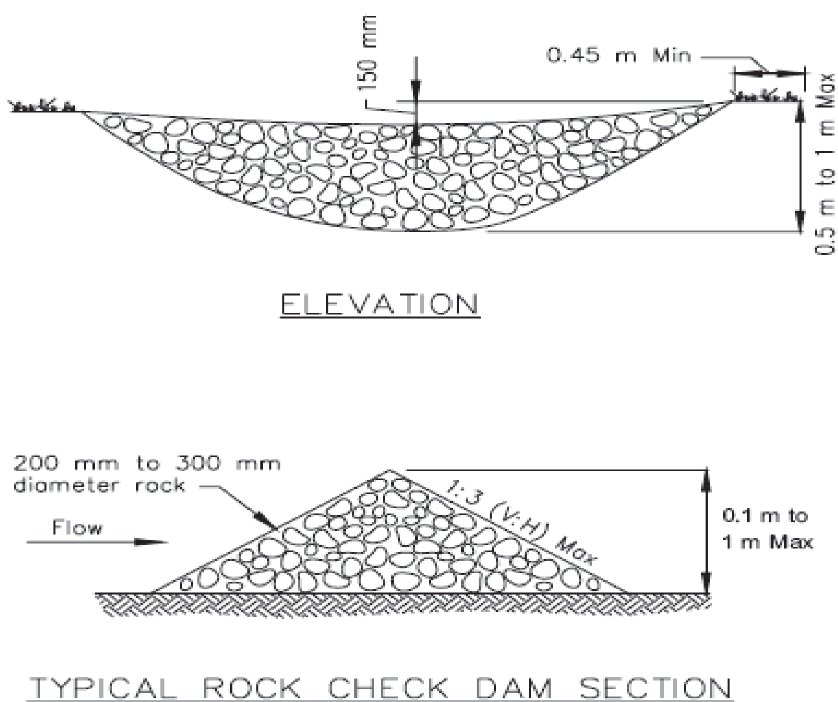
Check Dams

Description

A check dam is a small dam constructed across a drainage ditch, swale, or channel to lower the velocity of flow. Reduced runoff velocity reduces erosion and gullying in the channel and allows sediments to settle out. A check dam may be built from stone, sandbags (filled with pea gravel), logs, or concrete. Check dams are relatively easy and inexpensive to construct. Permanent check dams should be constructed from stone or concrete. Sandbag dams filled with pea gravel or logs are suitable only as temporary practices. Never use a filter fence or a hay bale as a check dam, either on a temporary or permanent basis.

Applicability

Use check dams where temporary channels or permanent channels are not yet vegetated, channel lining is infeasible, where velocity checks are needed, or to induce stormwater exfiltration into the ground within a BMP such as a dry water quality swale. Check dams may also be used as a temporary or emergency measure to limit erosion by reducing flow in small open channels. Other uses for



CHECK DAM
NOT TO SCALE
adapted from Caltrans Stormwater Handbooks

check dams include:

- To reduce flow in small temporary channels that are presently undergoing degradation,
- Where permanent stabilization is impractical due to the temporary nature of the problem,
- To reduce flow in small eroding channels where construction delays or weather conditions prevent timely installation of non-erosive liners.

Check dams can be installed in small open channels that drain 10 acres or less, or channels where stormwater velocities exceed 5 feet per second. Note that some BMPs such as grass channels require flows to not exceed 1 foot per second for the water quality volume. Check dams cause water to pond. Under low-flow situations, water ponds behind the structure and then slowly seeps through the check dam and/or exfiltrates into the underlying soil, depending on the soil permeability. Under high-flow situations, water flows over and/or through the structure.

Advantages

- Inexpensive and easy to install.
- Reduces velocity and may provide aeration of the water.
- Prevents gully erosion from occurring before vegetation is established, and also causes a high proportion of the sediment load in runoff to settle out.
- In some cases, if carefully located and designed, check dams can remain as permanent installations with very minor regrading, etc.
- They may be left as either spillways, in which case accumulated sediment would be graded and seeded, or as check dams to capture sediment coming off that site.
- They must be constructed in dry water quality swales to reduce velocity and induce exfiltration.

Disadvantages

- May kill grass linings in channels if the water level remains high after rainstorms or if there is significant sedimentation.
- Clogging by leaves in the fall may be a problem.
- Should not be used in live streams
- Promotes sediment trapping but resuspension can occur during subsequent storms
- Require extensive maintenance following high velocity flows
- Should not be made from straw bales or silt fences

Design

Install check dams at a distance and a height to allow small pools to form behind them. Install the first check dam about 15 feet from the outfall device and at regular intervals after that, depending on slope and soil type. In multiple check dam installations, design the system so that backwater from the downstream check dam reaches the toe of the next upstream dam. High flows (typically a 2-year or larger storm) should flow over the check dam without increasing upstream flooding or damaging the dam. Form check dams by hand or mechanically. Never dump rock directly into the channel or swale. Rock check dams should consist of well-graded stone consisting of a mixture of rock sizes.

When used in dry water quality swales, the height of the check dam shall be no less than the elevation associated with the Water Quality Volume (1/2 inch or 1-inch times contributing impervious surface).

Exercise care in designing the ends of a check dam to ensure that it is long enough and adequately anchored to prevent ponded water from scouring the soil at the ends, and flowing around the dam.

Some check dam designs may require weirs. For example, if the same check dam is used for water quality treatment (for the water quality volume), and to lag the peak rate of runoff (for the velocity associated with runoff from the 2-year storm), a weir must be included as part of the check dam design. In instances where a permanent check dam is to be used for both water quality treatment and lag peak flows with a weir, use a durable material such as concrete. If the check dam is constructed from stone such as pea gravel, the weir would most likely lose its shape when higher velocities occur.

Maintenance

Inspect check dams after every significant rainfall event. Repair damage as needed. Remove sediment as needed.

Adapted from:
Caltrans, Storm Water Quality Handbooks. Section 4. SC-4 P.
MassDEP, Massachusetts Nonpoint Source Pollution Management Manual, 2006. http://www.mass.gov/dep/water/laws/policies.htm#storm

OUTLET STRUCTURES

Description

Outlets of BMPs are devices that control the flow of stormwater out of the BMP to the conveyance system.

Outlet Protection Design in Relation to Receiving Wetlands

This section describes the various types of common outlets such as flared end structures, risers, single-stage outlets, and multi-stage outlets. Considerations include setting back the outlet from a brook, providing appropriate energy dissipation, and orientating the outlet to reduce scour effects on the opposite bank.

Alignment of Outlets into Regulatory Streams

The Wetlands and 401 regulations require that stormwater treatment be provided prior to discharge into wetland resource areas such as vegetated wetlands (BVW, IVW, salt marshes), land under water (streams, lakes, rivers, ponds, ocean), and other resource areas, except for Riverfront Areas ILSF, BLSF, and land subject to coastal zone flowage, where such practices may be sited, provided the structures meet the performance standards specified in the Wetland regulations applicable to all projects.

The impact of new pipe outfalls on wetlands can be significantly reduced by locating the outfall point back from the receiving stream, using a flared-end structure, installing riprap or bio-engineered splash pad, and either digging a channel from the outfall to the stream or designing the splash pad to act as a level spreader to sheet the discharged stormwater to the stream.

In addition to not placing the outfall and energy dissipation in a wetland resource area such as a BVW or LUW, care must be exercised in the outlet design to ensure its orientation is such to reduce scour at the entry point and opposite bank. The preferred approach is to end the outlet pipe at a headwall or flared-end structure with a riprap or bio-engineered splash pad, discharging to a manmade drainage swale that is aligned at no more than a 45 degree angle to a stream channel. Design the outlet point and riprap or bio-engineered splash pad to reduce the energy sufficiently to eliminate a need to install riprap on the bank opposite the outfall point to protect it from scour.

References for BMP Accessories:

Note that sections of the Massachusetts Stormwater Update were adapted from a variety of manuals, checklists and other references in the public domain previously developed by other states and federal agencies, including:

Caltrans, Storm Water Quality Handbooks. 2003. (http://www.dot.ca.gov/hq/construc/stormwater/manuals.htm)

Connecticut Department of Environmental Protection. Connecticut Stormwater Quality Manual. 2004. (http://dep.state.ct.us/wtr/stormwater/strmwtrman.htm)

Idaho Department of Environmental Quality. Catalog of Stormwater BMPs for Cities and Counties. March 2003. (http://www.google.com/u/DEQ?q=stormwater&domains=www.deq.idaho.gov&sitesearch=www.deq.idaho.gov)

Maine Department of Environmental Protection. Maine Stormwater Best Management Practices Manual. January 2006. (http://www.maine.gov/dep/blwq/docstand/stormwater/stormwaterbmps/index.htm)

Maryland Department of the Environment. Maryland Stormwater Design Manual, Volumes I and II, October 2000. (http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp)

New Jersey Department of Environmental Protection. New Jersey Stormwater Best Management Practices Manual. April 2004. http://www.state.nj.us/dep/stormwater/bmp_manual2.htm

U.S. Department of Transportation. Federal Highway Administration. Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring. (Undated). (http://www.fhwa.dot.gov/environment/ultraurb/index.htm)

U.S.Environmental Protection Agency. Office of Research and Development. The Use of Best Management Practices (BMPs) in Urban Watersheds. EPA/600/R-04/184. September 2004.

Vermont Agency of Natural Resources. The Vermont Stormwater Management Manual. April 2002. (http://www.vtwaterquality.org/stormwater.htm)