STORMWATER MANAGEMENT REPORT

Curve Hill Road - Yarmouth, MA

August 2024

Yarmouth Stormwater Design and Implementation Project

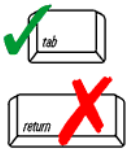
Partner: Association to Preserve Cape Cod
Owner/Operator: Town of Yarmouth

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

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 for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☐ An Illicit Discharge Compliance Statement is attached;

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

STORMWATER MANAGEMENT REPORT

CURVE HILL ROAD
YARMOUTH STORMWATER DESIGN AND IMPLEMENTATION PROJECT
YARMOUTH, MA

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Under Notice of Intent (NOI) Cover

APPENDICES

EXECUTIVE SUMMARY

The purpose of this report is to describe existing and proposed drainage conditions of the Curve Hill Road site (UBR-4) in Yarmouth, as well as proposed green stormwater infrastructure (GSI) structures and management strategies to reduce stormwater impacts. This project is part of efforts to improve water quality in the Town of Yarmouth by reducing pollutant loads in stormwater runoff, specifically nitrogen, bacteria, and sediment. The Curve Hill Road site was identified as a priority stormwater retrofit in a CZM-funded assessment focused on green infrastructure Stormwater Control Measures (SCMs) and low impact design.

The main goal for this site is to capture, manage and treat stormwater runoff from Great Western Road and Curve Hill Road prior to discharging to a wetland.

This project involves the development of new GSI systems at a non-developed Town-owned property to treat the first flush of pollutants (the Water Quality Volume (WQV), or first 1 inch of runoff) of the area draining to the site.

The project includes the following structural SCMs:

- Constructed wetland to provide treatment of pollutants and infiltration, and
- Proprietary water quality treatment unit.

Since the proposed stormwater management system is a retrofit project undertaken solely to improve water quality at the site, it falls under the redevelopment category in accordance with the Massachusetts Stormwater Management Standards (MASMS 2008), as described in Massachusetts Stormwater Handbook, Volume 1 Chapter 1. As a redevelopment project, the design is required to meet the MASMS standards to the maximum extent practicable (MEP).

As shown in **Table 1,** the proposed project meets or exceeds each standard**,** except the recharge standard that is not applicable. The proposed constructed wetland is designed to capture and treat the full one inch of runoff of the contributing drainage area. Overall, this project will reduce on-going impacts to Bass River.

Table 1. Project MASMS Compliance Summary

	Minimum Standard	Type	Compliance	Report Reference(s)
1	**New Stormwater Conveyances**	Narrative	Yes	Section 3.3
2	**Water Quantity**	Calculation	Yes	Section 4.3/Table 6/Appendix B
3	**Recharge**	Calculation	N/A	Section 4.2 /Appendix B
4	**Water Quality**	Calculation	Yes	Section 4.1/Table 3/Table 4/Appendix B
5	**Land Uses with Higher Potential Pollutant Loading**	Narrative	N/A	Section 2.0
6	**Critical Areas**	Narrative	N/A	Section 4.1
7	**Redevelopment**	Narrative	Yes	Section 4.0
8	**Erosion Control**	Narrative	Yes	Section 4.4/Appendix F
9	**Operation and Maintenance**	Narrative	Yes	Section 4.5/Appendix D
10	**Illicit Discharges**	Narrative	Yes	Section 4.6

1.0 INTRODUCTION

This report provides a summary of the stormwater management systems proposed for Curve Hill Road in Yarmouth, MA. The Yarmouth Department of Public Works is proposing this project in collaboration with the Association to Preserve Cape Cod (APCC) as a part of a town effort (Yarmouth Stormwater Design and Implementation Project) to improve water quality in the Town of Yarmouth. The proposed project has been designed to retrofit existing impervious areas for water quality improvements and improving overall site conditions. This report describes the existing and proposed site conditions and the practices to be implemented to reduce stormwater discharges and pollutants during and after construction. As required for retrofit projects, the stormwater system for the project has been designed to conform to the requirements of the Massachusetts Stormwater Management Standards (MASMS) to the maximum extent practicable.

1.1 Background

Coastal embayments across Cape Cod are significantly degraded by nutrient and bacteria impairment. Land uses, including stormwater runoff and fertilizer use, contribute on average 20% of the controllable nitrogen load within our coastal watersheds (Cape Cod Commission 208 Plan, 2015) and bacterial contamination, including cyanobacteria, regularly causes closures of beaches. It's been reported (APCC's 2022 State of the Waters) that 90% of the coastal embayments and 39% of the freshwater ponds assessed received unacceptable water quality scores. These high nutrient loads are of concern for the environment, our coastal economy, and public health as they negatively impact habitat for fish and shellfish and can result in unsafe conditions for swimming, fishing and boating.

As part of a Coastal Zone Management (CZM) Coastal Habitat and Water Quality Grant, the Town of Yarmouth Department of Public Works (DPW), APCC and Horsley Witten Group (HW) completed a comprehensive assessment and stormwater management plan identifying and prioritizing stormwater retrofit sites on the south shore of Yarmouth. Concept designs were ranked based on various criteria including potential pollutant removal (i.e., load and drainage area), water quality status of the associated waterbody, construction cost and feasibility, and additional human use and resource benefits (restored shellfish and anadromous fish habitat, proximity to environmental justice communities, improved climate resiliency, opportunity for public education, etc.). With additional support from a second Coastal Habitat and Water Quality Grant, 25% designs were developed for five high-ranking priority sites, and two sites were chosen to advance to 75% designs and permitting, including this one on Curve Hill Road. Funding is available to further advance the two priority sites through 100% design and construction.

1.2 Project Goals

The purpose of this project is to improve water quality in Bass River by reducing or eliminating pollutant loads from stormwater runoff from Great Western Road and Curve Hill Road using GSI SCMs. Specifically, the project aims to maximize pollutant removal (% bacteria, nitrogen and phosphorus) and water quality volume treated.

1.3 Design Methodology

The design was completed by the following tasks:

- Preliminary field assessment of the site and contributing drainage area to identify usage, physical and environmental constraints and opportunities, and long-term operation and maintenance concerns;
- Determination of drainage areas and land coverage within the project area;
- Selection of structural SCMs best suited to site conditions and project goals;
- Structural SCM sizing and performance estimates (described further below);
- Hydrologic/Hydraulic Modeling (described further below);
- Grading and layout of site plan;
- Erosion control plan development; and
- Operation and maintenance (O&M) plan development.

SCM Performance Estimates

The proposed SCMs were selected and sized to maximize pollutant load removals. Since the waterbodies this site drains to are shellfish growing areas, have water quality impairments and are subject to TMDLs, the SCMs were chosen to maximize not only total suspended solids (TSS) removal, but total nitrogen (TN), total phosphorus (TP) and bacteria load reductions as well. MASMS was used as a reference for TSS removal estimates for constructed wetlands, but the more recently developed pollutant load removal curves (USEPA 2021 & Paradigm Environmental 2019) were used for TP, TN, and bacteria.[1]

Hydrologic/Hydraulic Modeling

Existing and proposed conditions for the project area were modeled using HydroCAD software, which combines USDA Natural Resources Conservation Service hydrology and hydraulic techniques (commonly known as SCS TR-55 and TR-20) to generate hydrographs. Conditions were evaluated for the water quality event (storm that produces 1 inch of runoff, or a roughly 1.2-inch rain event) as well as larger storm events, including the 2-, 10-, 25- and 100-year 24-hour Type III storm events. The rainfall depths used for each storm event are the NOAA+ values (NOAA Atlas 14 90% Upper Confidence value multiplied by 0.9) (NOAA NWS, 2017). Rainfall values are included in **Appendix A**.

2.0 Existing Conditions

The Curve Hill Road site (UBR-4) is located along the southern side of Curve Hill Road on Town-owned property between Curve Hill Road and Four Seasons Drive, on the western side of Yarmouth, approximately half a mile west of Bass River. Drainage infrastructure (e.g., catch basins, manholes, and pipes) located along Great Western Road discharges via an outlet pipe to the site. Visual observations on site indicate sediment accumulation, as the discharge pipe was difficult to field locate, which is likely because the drainage area to the Great Western Road infrastructure is large. Runoff from Curve Hill

[1] It is important to note that these curves have a crosswalk to help users determine which specific curve to reference: for constructed wetlands, the appropriate curve is the Wet Pond Performance Curve.

Road flows into a paved flume and discharges into the project site, close to the discharge pipe from Great Western Road. The site is surrounded by residential properties, except for sections to the north and southwest where it directly borders the Curve Hill Road Right-of-Way. The Blue Rock Golf Course is located to the west of the site, just beyond the residential lots on the west side of Curve Hill Road. The Curve Hill Road project site is not developed and upgradient of an existing wetland. The site's land use is not classified as a land use with higher potential pollutant loads (LUHPPL) and thus, is not subject to MASMS **Standard 5**.

2.1 Receiving Water and Watershed

Great Western Road and Curve Hill Road runoff discharges into a wetland, which ultimately discharges into Bass River that opens into Nantucket Sound. Bass River provides habitat for shellfish growing areas. However, it is listed as impaired for total nitrogen and fecal coliform by the most recent Massachusetts DEP 303(d) – 2022 Integrated list of Waters.

Bass River is located in the Bass River Watershed, for which TMDL documents has been developed for nitrogen, fecal coliform, nutrient/eutrophication biological indicators, and estuarine bioassessments. The full list of impairments for this portion of the watershed is listed below, and a map showing these resources is included in **NOI Narrative Figure 7**:

- Bass River (MA96-118) "Grand Cove" portion, Yarmouth, Bass River Watershed – Impaired for total nitrogen and nutrient/eutrophication biological indicators; Category 4a (TMDL completed) of the 2018/2020 Integrated List of Waters.
- Bass River (MA96-12) Headwaters outlet, Yarmouth, Bass River Watershed – Impaired for total nitrogen, fecal coliform, and estuarine bioassessments; Category 4a (TMDL completed) of the 2018/2020 Integrated List of Waters.

2.2 Drainage Area

The Curve Hill Road project site existing contributing drainage area is approximately 13.0 acres. This area consists of undisturbed forest, residential properties, small lawn areas, and roads. Based on existing topography and flow paths, the total drainage area was divided into three separate drainage areas: DA1 (area draining to the proposed site), DA2A (area draining to the existing paved flume on Curve Hill Road), and DA2B (area draining to the Great Western Road discharge pipe). DA2B is the largest drainage area (approximately 9.0 acres), as it includes all of the area draining to the existing drainage infrastructure along Great Western Road. All drainage areas drain to the wetland, modeled as Study Point 1 (SP1).

See the existing drainage area map and detailed breakdown of land cover in **Appendix A**, as well as the existing HydroCad model report in **Appendix B**.

2.3 Resource Areas

HW wetland biologists delineated several resource areas at the site in November 2023. A full description of these resource areas is included in **NOI Narrative**, and their locations and associated buffers are

shown on the plans in **Appendix F**. The only wetland resource areas identified at the site are the Bordering Vegetated Wetland and the Other Areas of Flood Hazard FEMA Zone X. Invasive plant species were not observed to be significantly present at the site. This site is not considered a critical area and it is not subject to MASMS **Standard 6**.

2.4 Soils

Soils data from the Natural Resources Conservation Service (NRCS) indicate that the soils within the drainage area are composed of Carver coarse sand, at 3-8% slopes, and Freetown and Swansea mucks, 0-1% slopes. Carver coarse sand is hydrologic soil group A (HSG) and hydrologic soil group B (HSG) and Freetown and Swansea mucks are hydrologic soil group B/D (HSG), as shown in **NOI Narrative Figure 5** of the NOI application.

One test pit (TP) was conducted at the site on January 4, 2024 in the Town right-of-way on the southern side of Curve Hill Road near 7 Curve Hill Road. The test pit aimed to evaluate subsurface conditions and estimate seasonal high groundwater (ESHGW) based on evidence of mottling or redox. Since no mottling or redox was observed, the groundwater observed in the test pit was adjusted based on the Frimpter Method (USGS, 2022; Cape Cod Commission, 2006; Cape Cod Commission, 2024)[2]. The test pit was witnessed and logged by a HW Massachusetts Title 5 Approved Soil Evaluator, with the results shown in **Table 2** below. See **Appendix C** for soil test pit logs.

When designing constructed wetlands, the permanent pool is at groundwater elevation. The wetland downgradient of the project site was delineated between elevation 6.8 and 8.0 feet closest to the proposed outlet of the constructed wetland. For this reason, the permanent pool of the constructed wetland was designed conservatively at 7.5 feet elevation.

Table 2. Test Pit (TP) Results

Test Pit ID	Surface Elevation at TP (ft)	Pit Bottom Elevation (ft)	Observed GW (ft)	ESHGW Elevation (ft)	Soil Texture(s) at SCM	Notes
TP-1	11.2	5.0	6.0	8.0	Coarse sand	

3.0 Proposed Conditions

The proposed project consists of the following stormwater improvement:

- GSI including constructed wetland.

The proposed GSI system is designed to meet the following major objective:

[2] Index Well Mashpee 29 (MIW-29) Zone B adjustment factor in January 2024 of 2.0 feet was used to adjust the observed groundwater to develop the ESHGW of 8.0 feet.

- Capture, treat, and infiltrate to the maximum extent practicable the first one inch of runoff (Water Quality Volume (WQV)).

3.1 Drainage Areas

The Curve Hill Road site contributing drainage area under proposed conditions is the same as existing conditions, with a total of approximately 13.0 acres. While DA2A and DA2B remain the same, DA1 includes the proposed constructed wetland as a pond so that it can be accurately modeled in HydroCAD. All drainage areas drain to the wetland, modeled as Study Point 1 (SP1), which is the same as existing conditions.

See the proposed conditions drainage area map and a detailed breakdown of land cover in **Appendix A,** as well as the proposed HydroCAD model report in **Appendix B.**

3.2 Structural Stormwater Control Measures (SCMs)

The proposed stormwater management includes a GSI approach to capture, detain, and treat runoff. The stormwater management systems were designed to meet **Standard 1**, so that no new untreated stormwater runoff will be directed to any off-site areas or resource areas.

There is one stormwater GSI practices proposed: constructed wetland. Pretreatment will be provided with a water quality unit. These SCMs are described in more detail below.

Pretreatment

A proprietary water quality unit (WQU) is provided for pretreatment of the runoff from the paved surfaces to allow for sediment and other debris to settle out prior to conveyance into the constructed wetland.

Constructed Wetland (CW)

Stormwater constructed wetlands mimic natural wetlands to manage and treat stormwater by allowing settling of sediments and filtering stormwater through a mix of native vegetation. The system consists of an inflow component, a series of pools of varying depths, a reverse slope pipe and overflow spillway for discharge. Stormwater is designed to be directed to the stormwater constructed wetland off of Great Western Road through the existing drainage outfall pipe and off of Curve Hill Road via a drop inlet into a water quality unit.

4.0 Stormwater Design Components

The proposed SCMs were designed to meet a variety of goals and regulatory requirements as discussed above. As a retrofit project for managing existing impervious cover, this design must specifically comply with the redevelopment standard (MASMS **Standard 7)** by meeting all standards to the maximum extent practicable. The project fully meets this standard, as described in detail below.

4.1 Water Quality

The main purpose of this retrofit project is to improve water quality. This section describes the treatment volumes and pollutant load reductions achieved by the proposed design and how they compare to the MASMS standards.

Treatment Volume

Per **Standard 4** of MASMS, the stormwater management system for a new development site within soils with a rapid infiltration rate (greater than 2.4 inches per hour) must be sized to treat the first one inch of runoff and remove 80% or more of the annual post-construction load of total suspended solids (TSS). As a retrofit (falls under **Standard 7** - Redevelopment), the project is only required to meet this to the maximum extent practicable. However, the proposed SCMs were sized to treat the full one-inch water quality volume (WQv) for their contributing drainage areas (DA1, DA2A, and DA2B). The proposed HydroCAD model results showing treatment of the water quality volume are included in **Appendix B** and summarized below in **Table 3**.

Table 3. Compliance with Water Quality Volume (WQV) Requirements

DA ID	SCM ID	IA (ac)	WQv Goal (ac-ft)	WQv Provided (ac-ft)*	% WQv Provided	Meets Reqt?	Notes
DA1	CW	0.28	0.346	0.346	100%	Y	
DA2a		0.51					
DA2b		3.36					
TOTAL SITE:		**4.15**	**0.346**	**0.346**	**100%**	**Y**	

**Impervious Area*

***From HydroCAD results – see Appendix B for volume "discarded" for WQv Event*

Pollutant Load Reductions

The proposed constructed wetland meet the MASMS requirements for TSS removal and maximize removals of the other pollutants of concern. Estimated TSS, TP, TN, and bacteria removals for the proposed project are provided in **Table 4.** The proposed O&M Guide in **Appendix D** was developed to ensure that the stormwater system continues to function as it was designed into the future to maintain these levels of pollutant removal.

Table 4. Compliance with Water Quality Pollutant Load Reduction Requirements

DA ID	SCM ID	IA (ac)	WQv Provided (ac-ft)*	Runoff Depth Treated (in)	TSS Removal (%)**	TP Removal (%)***	TN Removal (%)***	Bacteria Removal (%)****	Meets Reqt?	Notes
DA1	CW	0.28	0.346	1.00	80%	53%	32%	65%	Y	
DA2a		0.51								
DA2b		3.36								
TOTAL SITE:		**4.15**	**0.346**	**1.0**	**80%**	**53%**	**32%**	**65%**	**Y**	**MEP for retrofit projects**

**From HydroCAD results – see Appendix B for volume "discarded" for WQv Event*
***From MASMS*
****From MS4 NPDES Permit Appendix F Attachment 3 (USEPA 2021)*
*****From Paradigm Environmental (2019)*

The proposed constructed wetland discharges to an existing wetland and is not designed to infiltrate, so MASMS **Standard 6** is not applicable. However, the project site is located within the Bass River Watershed and as the project goal is to improve water quality, the proposed constructed wetland was designed to meet MASMS **Standard 6.** The CDS water quality unit is proposed for pretreatment prior to discharge into the constructed wetland, providing greater than 44% TSS removal. Furthermore, constructed wetlands are recommended treatment SCMs for areas that discharge near to shellfish growing areas. Therefore, this project meets **Standard 6**.

Long-term Pollution Prevention Plan

Source control is important to ensure long-term functionality of the proposed SCMs and protect downstream resources and habitat. A long-term pollution prevention plan specific to this site is provided as a part of the O&M Guide in **Appendix D**.

4.2 Recharge

For new development projects, the MASMS requires a specific annual "recharge" volume (Rev) based on the HSG of the soil covered by new impervious surfaces. However, infiltrating treated runoff is not a goal of this project due to the site proximity to groundwater, and therefore, the project does not take credit for recharge.

4.3 Water Quantity

The main focus of this project is to improve water quality and habitat, but reducing water quantity impacts during large storm events was also considered. The proposed constructed wetland will reduce peak flows and runoff volumes for the 2-, 10-, 25- and 100-year storms. The existing and proposed HydroCAD model results for these larger storm events are included in **Appendix B,** and the resulting peak flows and runoff volumes are summarized below in **Table 6** for both existing (EX) and proposed

(PR) conditions. These results show that the proposed improvements will reduce peak flows and runoff volumes for all evaluated storms, and thus, fully meet the requirements of **Standard 2** of the MASMS.

Table 5. Summary of Existing and Proposed Condition Peak Flow Rates and Runoff Volumes

Study Point		Peak Flow, cfs				Runoff Volume, acre-ft			
		2-yr	10-yr	25-yr	100-yr	2-yr	10-yr	25-yr	100-yr
SP1	EX	13.98	20.58	26.28	39.41	1.169	1.859	2.485	3.681
	PR	9.28	11.83	18.19	33.80	0.896	1.585	2.211	3.407
Reduction	**%**	**-34%**	**-43%**	**-31%**	**-14%**	**-23%**	**-15%**	**-11%**	**-7%**

**From HydroCAD results – see Appendix B*

4.4 Erosion Control

Controlling erosion and sedimentation from the construction site is important to meet the overall water quality goals of this retrofit project, as well as to meet MASMS **Standard 8**. Given this site's size (< 1 acre of disturbance), a NPDES Construction General Permit Stormwater Pollution Plan (SWPPP) is not required. However, planning for effective erosion and sediment controls (ESCs) was important to this project's design, and so an ESC Plan is included in the design plans (**Appendix F**), along with a detailed sequence of construction activities and ESC notes. Silt socks are proposed along the downgradient edges of the area of disturbance. Regular street sweeping is to be provided along Curve Hill Road to minimize tracking of sediment. Areas for other sediment traps/basins should be provided on an as-needed basis. Disturbed areas will be stabilized as soon as possible to minimize erosion and sedimentation with pavement, seeding and/or erosion control blankets, if necessary. A Pollutant Controls During Construction guide is also included in **Appendix E** that discusses these controls in more detail. With these layered ESCs implemented throughout the site, discharge of sediment-laden runoff during construction should be minimized to the maximum extent practicable.

The contractor will be required to establish these erosion controls prior to beginning any other project-related work. The ESC Plan will also establish the limit of work, beyond which the contractor will not be allowed to perform any work. It is the contractor's responsibility to monitor and correct erosion control practices throughout the duration of the project. Erosion control measures will not be removed until the project reaches completion as directed by the project engineer or landscape architect.

4.5 Operation and Maintenance

Ongoing maintenance is vital for long-term success at the site. The SCM was designed to be low-maintenance in nature. The SCM will be operated and maintained appropriately during construction and post-construction as required on the construction drawings and O&M Guide per MASMS **Standard 9** (**Appendix D and F**).

4.6 Illicit Discharges

There will be no illicit discharges to the existing system by the proposed project per MASMS **Standard 10**. The Long-Term Pollution Prevention Plan in the O&M Guide (**Appendix D**) includes measures to prevent future illicit discharges.

5.0 REFERENCES

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FIGURES

APPENDIX A – Drainage Areas

- Existing and Proposed Drainage Areas Maps
- Land Coverage Summaries

0 150
SCALE IN FEET

VIKING ROCK ROAD
NARROWS LANE
PAINE ROAD
CURVE HILL ROAD
GREAT WESTERN ROAD
4 SEASONS DRIVE

252A A
252B A
252C A
252D A
52 D

DA1 0.28 1.89
DA2A 0.51 2.10
DA2B 3.27 9.01
SP1

LEGEND

DRAINAGE AREA BOUNDARY
IMP. AREA / TOTAL AREA (ACRES)
WOODS
WATER
ROOFTOP
GRASS
PAVEMENT
0.75 / 2.00

DA1 DRAINAGE AREA
SP1 STUDY POINT
P1 POND

SOIL BOUNDARY
TIME OF CONCENTRATION FLOW PATH
5' MAJOR CONTOUR
1' MINOR CONTOUR
EX DRAINAGE STRUCTURE
EX DRAIN PIPE

SOIL TYPES

52 D — FREETOWN AND SWANSEA MUCKS 0-1% (HSG D)

252 A — CARVER COARSE SAND (HSG A)
252A 0-3% 252B 3-8%
252C 8-15% 252D 15-35%

Horsley Witten Group, Inc.
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90 Route 6A Sandwich, MA 02563
horsleywittengroup.com

Drawn By: MCL
Checked By: GK
Date: 4/25/24

SITE UBR-1: CURVE HILL ROAD
SOTRMWATER RETROFIT DESIGN AND IMPLEMENTATION 25% DESIGN PLANS
YARMOUTH, MASSACHUSETTS

Plan Set:

EXISTING DRAINAGE MAP

Prepared For:
Town of Yarmouth DPW
74 Town Brook Road
West Yarmouth, MA 02673
Phone: (508) 398-2231 ext. 1250

Project Number: 22108A

Sheet Number: 1 of 2

last modified: 06/24/24 printed: 06/24/24 by gk
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0 150
SCALE IN FEET

VIKING ROCK ROAD
NARROWS LANE
PAINE ROAD
CURVE HILL ROAD
GREAT WESTERN ROAD
4 SEASONS DRIVE

252A A
252B A
252C A
252D A
52 D

DA1 0.28 1.89
DA2a 0.51 2.10
DA2b 3.27 9.01
P1
SP1

LEGEND

DRAINAGE AREA BOUNDARY
IMP. AREA / TOTAL AREA (ACRES) 0.75 / 2.00
WOODS
WATER
ROOFTOP
GRASS
PAVEMENT

DA1 DRAINAGE AREA
SP1 STUDY POINT
P1 POND

SOIL BOUNDARY
TIME OF CONCENTRATION FLOW PATH
5' MAJOR CONTOUR
1' MINOR CONTOUR
EX DRAINAGE STRUCTURE
EX DRAIN PIPE

SOIL TYPES

52 D — FREETOWN AND SWANSEA MUCKS 0-1% (HSG D)

252 A — CARVER COARSE SAND (HSG A)
252A 0-3% 252B 3-8%
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Drawn By: MCL
Checked By: GK
Date: 4/25/24
Plan Set:

SITE UBR-1: CURVE HILL ROAD
SOTRMWATER RETROFIT DESIGN AND
IMPLEMENTATION 25% DESIGN PLANS
YARMOUTH, MASSACHUSETTS

PROPOSED DRAINAGE MAP

Prepared For:
Town of Yarmouth DPW
74 Town Brook Road
West Yarmouth, MA 02673
Phone: (508) 398-2231 ext. 1250

Project Number: 22108A

Sheet Number: 2 of 2

last modified: 06/24/24 printed: 06/24/24 by gk
H:\Projects\2022\22108 APCC Yarmouth\Drawings\CURVE HILL\22108A CURVE HILL RD DR.dwg

CURVE HILL, YARMOUTH STORMWATER YARMOUTH, MA	Calc'd by:	GSG
	Checked by:	GK
Existing Drainage Conditions	Date:	7/15/2024

DRAINAGE AREAS	
DA1	**Wetland**
DA2a	**Curve Hill Road**
DA2b	**Great Western Road**

NOAA 14+ 24-hr Type III (inches)	
WQv	1.21
1-yr	3.05
2-yr	3.60
5-yr	4.51
10-yr	5.27
25-yr	6.53
100-yr	8.59
500-yr	11.43

DA1	Wetland		
Cover type	Area, ft^2	Area, *ac*	Note
Paved	3,469	0.080	
Permeable		0.000	
Roof	8,516	0.196	
Water	0	0.000	
Woods	46,010	1.056	
Grass	24,504	0.563	
TOTAL	82,499	1.894	

Impervious		
Area, ft^2	Area, *ac*	Percent
11,985	0.275	15

DA2a	Curve Hill Road		
Cover type	Area, ft^2	Area, *ac*	Note
Paved	14,426	0.331	
Permeable	0	0.000	
Roof	7,938	0.182	
Water		0.000	
Woods	25,978	0.596	
Grass	43,234	0.993	
TOTAL	91,576	2.102	

Impervious		
Area, ft^2	Area, *ac*	Percent
22,364	0.513	24

DA2b	Great Western Road					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	110,080	2.527				
Permeable	0	0.000				
Roof	35,831	0.823				
Water	394	0.009				
Woods	81,217	1.864		**Impervious**		
Grass	165,043	3.789		Area, ft^2	Area, *ac*	Percent
TOTAL	392,565	9.012		146,305	3.359	37

ALL	***ALL EX AREAS COMBINED***					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	127,975	2.938				
Permeable	0	0.000				
Roof	52,285	0.378				
Water	394	0.000				
Woods	153,205	1.653		**Impervious**		
Grass	232,781	1.555		Area, ft^2	Area, *ac*	Percent
TOTAL	566,640	13.008		180,654	4.147	32

CURVE HILL, YARMOUTH STORMWATER YARMOUTH, MA	Calc'd by:	GK
	Checked by:	
Proposed Drainage Conditions	Date:	

DRAINAGE AREAS	
DA1	**Wetland**
DA2a	**Curve Hill Road**
DA2b	**Great Western Road**

NOAA 14+ 24-hr Type III (inches)	
WQv	1.21
1-yr	3.05
2-yr	3.60
5-yr	4.51
10-yr	5.27
25-yr	6.53
100-yr	8.59
500-yr	11.43

DA1	**Wetland**					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	3,469	0.080				
Permeable		0.000				
Roof	8,516	0.196				
Water	8,193	0.188				
Woods	37,790	0.868		**Impervious**		
Grass	24,531	0.563		Area, ft^2	Area, *ac*	Percent
TOTAL	82,499	1.894		11,985	0.275	15

DA2a	**Curve Hill Road**					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	14,426	0.331				
Permeable	0	0.000				
Roof	7,938	0.182				
Water		0.000				
Woods	25,978	0.596		**Impervious**		
Grass	43,234	0.993		Area, ft^2	Area, *ac*	Percent
TOTAL	91,576	2.102		22,364	0.513	24

DA2b	Great Western Road					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	110,080	2.527				
Permeable	0	0.000				
Roof	35,831	0.823				
Water	394	0.009				
Woods	81,217	1.864		**Impervious**		
Grass	165,043	3.789		Area, ft^2	Area, *ac*	Percent
TOTAL	392,565	9.012		146,305	3.359	37

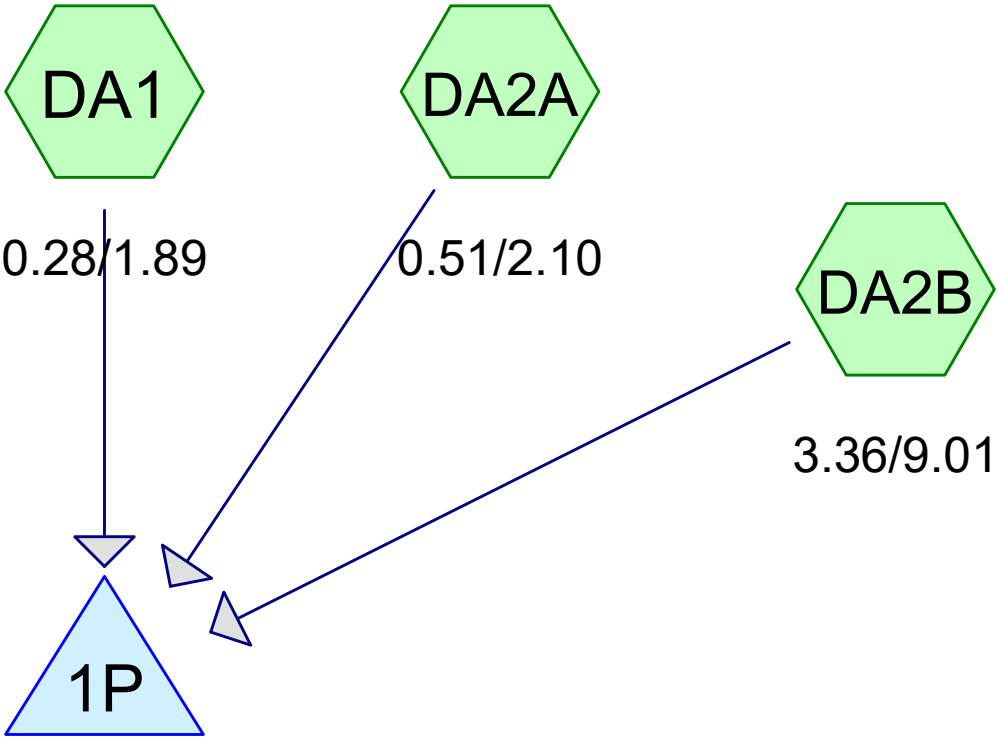
ALL	***ALL PR AREAS COMBINED***					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved	127,975	2.938				
Permeable	0	0.000				
Roof	52,285	1.200				
Water	8,587	0.197				
Woods	144,985	3.328		**Impervious**		
Grass	232,808	5.345		Area, ft^2	Area, *ac*	Percent
TOTAL	566,640	13.008		180,260	4.138	32

APPENDIX B – Hydrologic/Hydraulic Model Results

HydroCAD® Results

- Existing
- Proposed

Contech Water Quality Unit Removal Calculations



Curve Hill Wetland

Subcat Reach Pond Link

Routing Diagram for 22108 CURVE EX_report
Prepared by Horsley Witten Inc, Printed 8/9/2024

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2 YR	Type III 24-hr		Default	24.00	1	3.60	2
2	10 YR	Type III 24-hr		Default	24.00	1	5.27	2
3	25 YR	Type III 24-hr		Default	24.00	1	6.53	2
4	100 YR	Type III 24-hr		Default	24.00	1	8.59	2
5	WQ	Type III 24-hr		Default	24.00	1	1.21	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
5.344	39	>75% Grass cover, Good, HSG A (DA1, DA2A, DA2B)
0.080	98	Paved parking, HSG A (DA1)
1.200	98	Roofs, HSG A (DA1, DA2A, DA2B)
2.858	98	Unconnected pavement, HSG A (DA2A, DA2B)
0.009	98	Water Surface, HSG A (DA2B)
3.519	30	Woods, Good, HSG A (DA1, DA2A, DA2B)
13.010	**55**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
13.010	HSG A	DA1, DA2A, DA2B
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
13.010		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
5.344	0.000	0.000	0.000	0.000	5.344	>75% Grass cover, Good	DA1, DA2A, DA2B
0.080	0.000	0.000	0.000	0.000	0.080	Paved parking	DA1
1.200	0.000	0.000	0.000	0.000	1.200	Roofs	DA1, DA2A, DA2B
2.858	0.000	0.000	0.000	0.000	2.858	Unconnected pavement	DA2A, DA2B
0.009	0.000	0.000	0.000	0.000	0.009	Water Surface	DA2B
3.519	0.000	0.000	0.000	0.000	3.519	Woods, Good	DA1, DA2A, DA2B
13.010	**0.000**	**0.000**	**0.000**	**0.000**	**13.010**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)	Node Name
1	DA2B	0.00	0.00	1,259.0	0.0300	0.013	0.0	12.0	0.0	

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=0.49"
Tc=7.1 min CN=WQ Runoff=0.93 cfs 0.078 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=0.83"
Tc=7.1 min UI Adjusted CN=WQ Runoff=1.73 cfs 0.145 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=1.26"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=11.32 cfs 0.947 af

Pond 1P: Curve Hill Wetland Inflow=13.98 cfs 1.169 af
Primary=13.98 cfs 1.169 af

Total Runoff Area = 13.010 ac Runoff Volume = 1.169 af Average Runoff Depth = 1.08"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

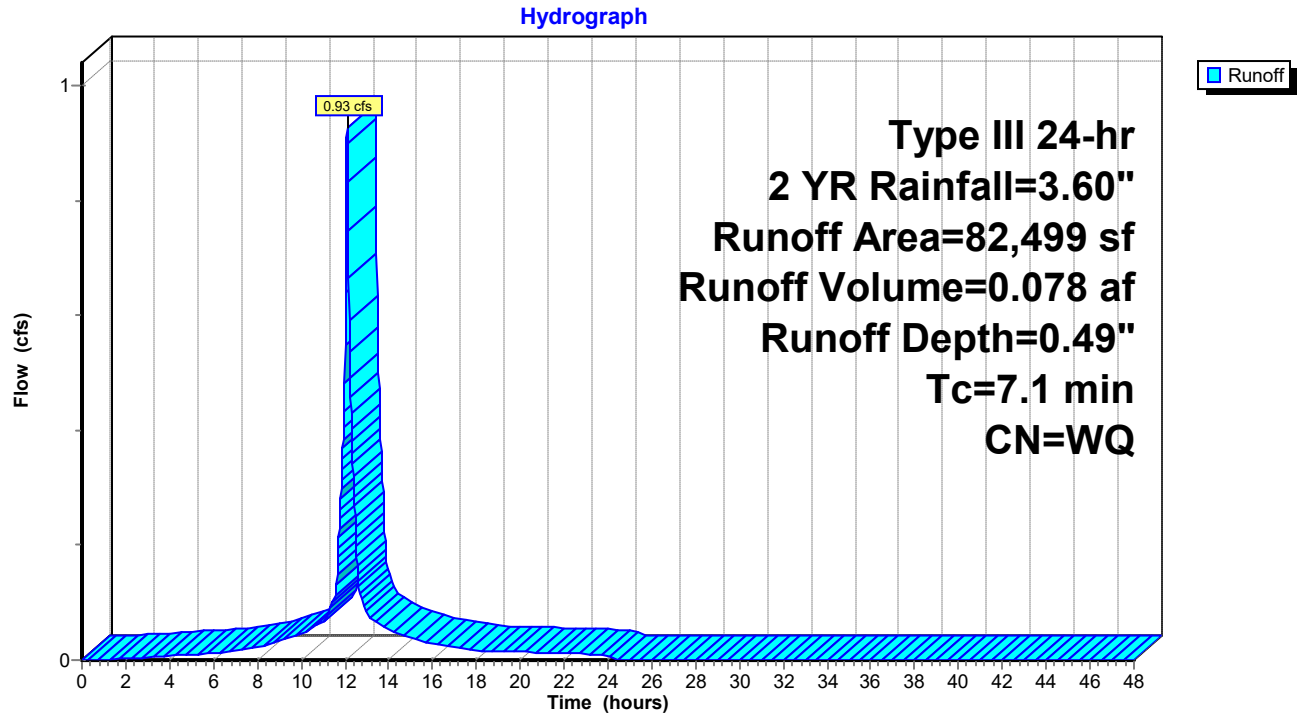
Runoff = 0.93 cfs @ 12.10 hrs, Volume= 0.078 af, Depth= 0.49"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2 YR Rainfall=3.60"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

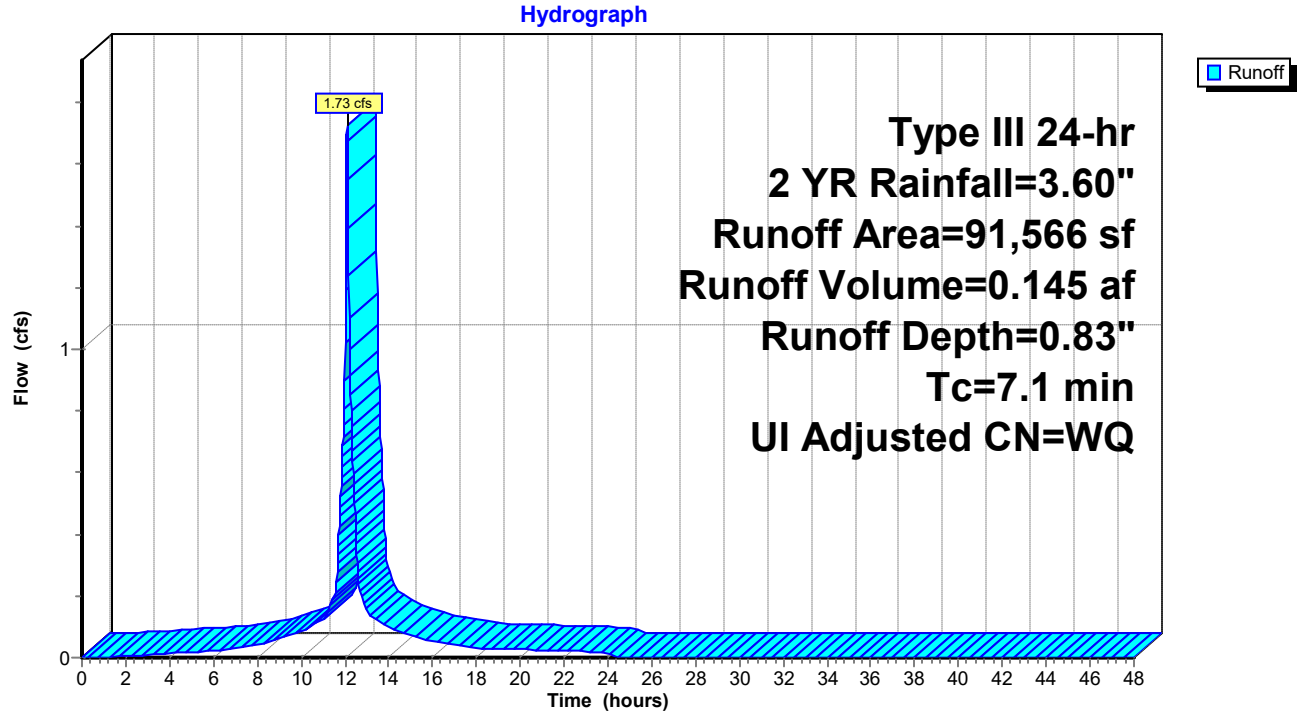
Runoff = 1.73 cfs @ 12.10 hrs, Volume= 0.145 af, Depth= 0.83"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2 YR Rainfall=3.60"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 183% of capacity of segment #3

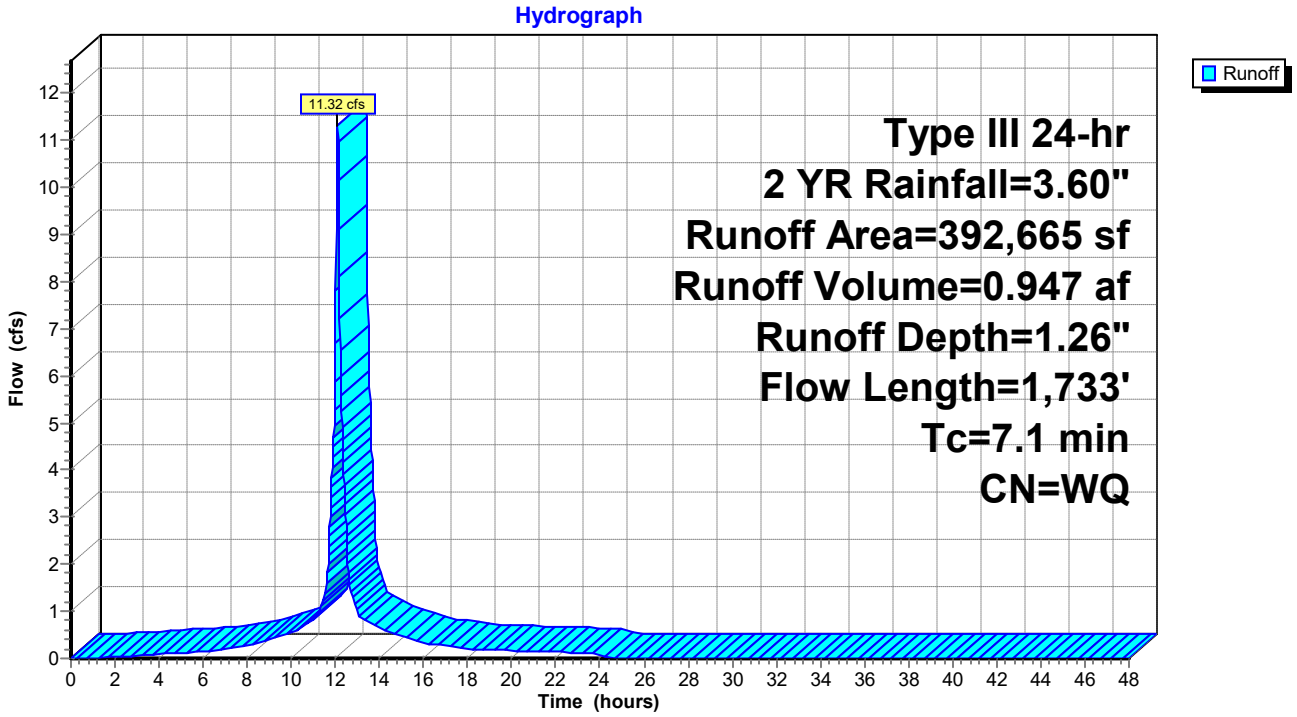
Runoff = 11.32 cfs @ 12.10 hrs, Volume= 0.947 af, Depth= 1.26"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2 YR Rainfall=3.60"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



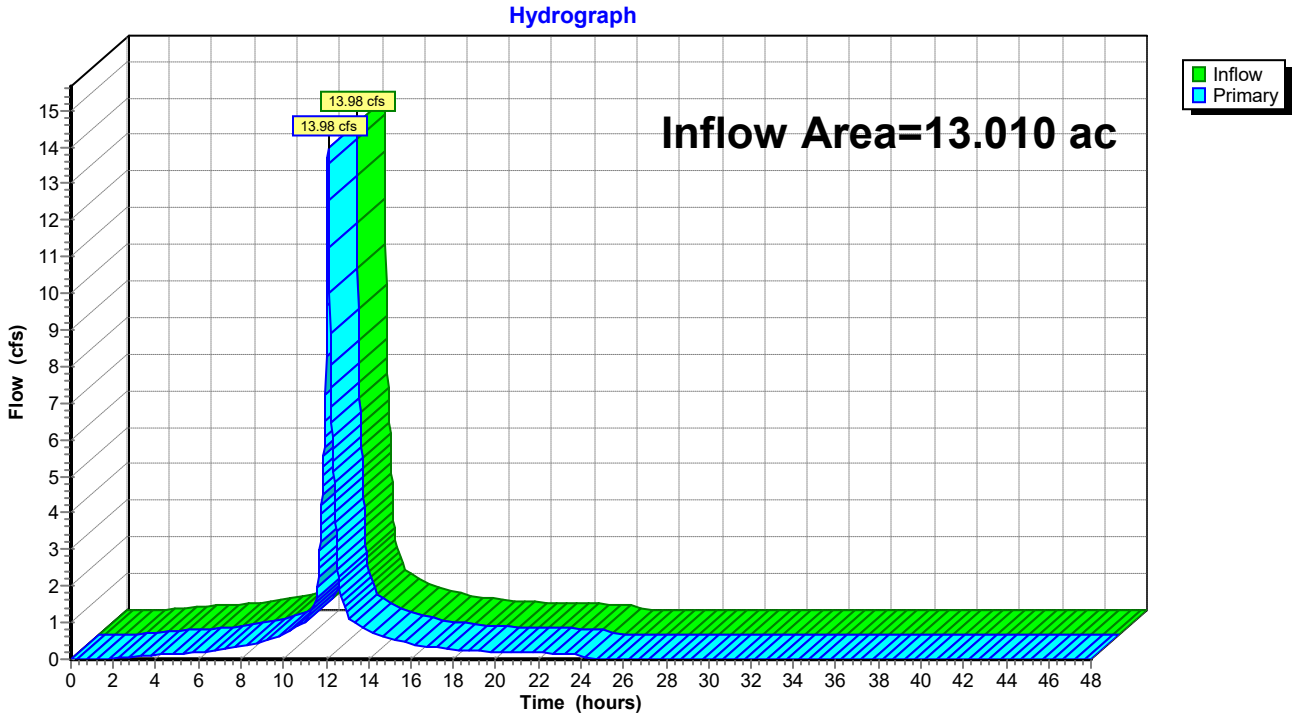
Summary for Pond 1P: Curve Hill Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 1.08" for 2 YR event
Inflow = 13.98 cfs @ 12.10 hrs, Volume= 1.169 af
Primary = 13.98 cfs @ 12.10 hrs, Volume= 1.169 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 1P: Curve Hill Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=0.82"
Tc=7.1 min CN=WQ Runoff=1.37 cfs 0.129 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=1.35"
Tc=7.1 min UI Adjusted CN=WQ Runoff=2.55 cfs 0.237 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=1.99"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=16.67 cfs 1.492 af

Pond 1P: Curve Hill Wetland Inflow=20.58 cfs 1.859 af
Primary=20.58 cfs 1.859 af

Total Runoff Area = 13.010 ac Runoff Volume = 1.859 af Average Runoff Depth = 1.71"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

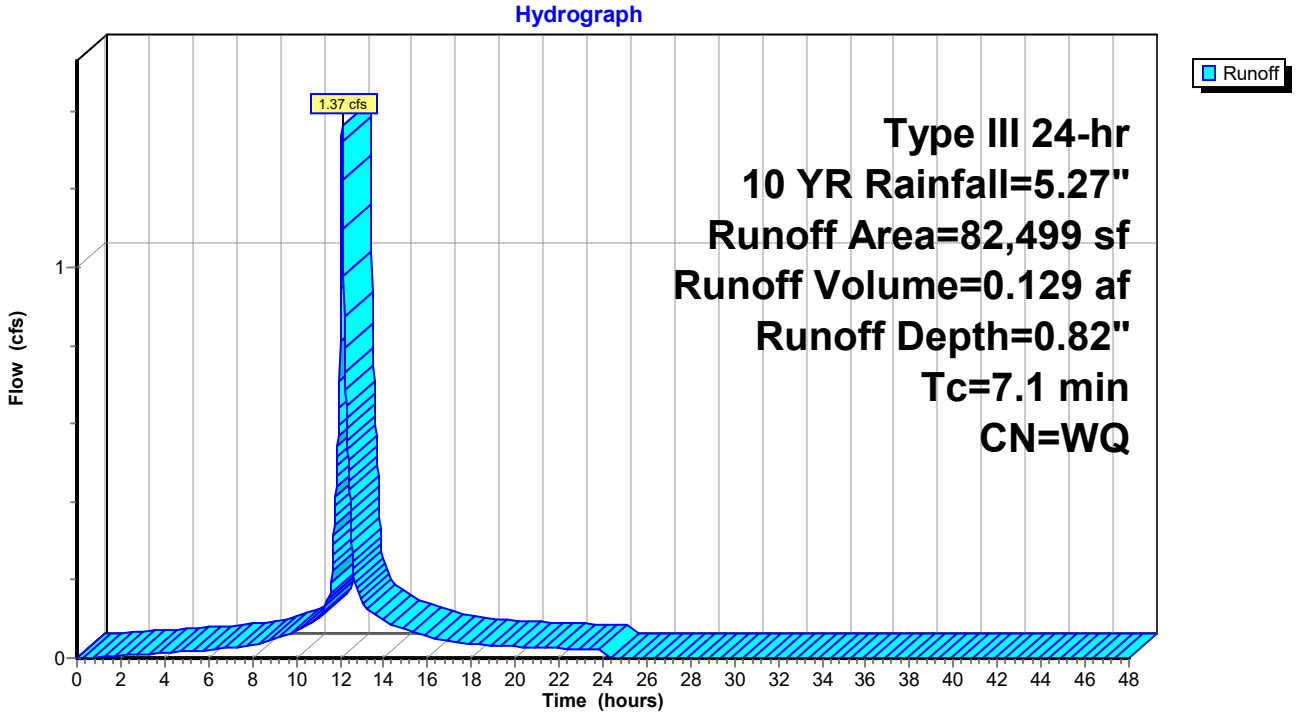
Runoff = 1.37 cfs @ 12.10 hrs, Volume= 0.129 af, Depth= 0.82"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 YR Rainfall=5.27"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

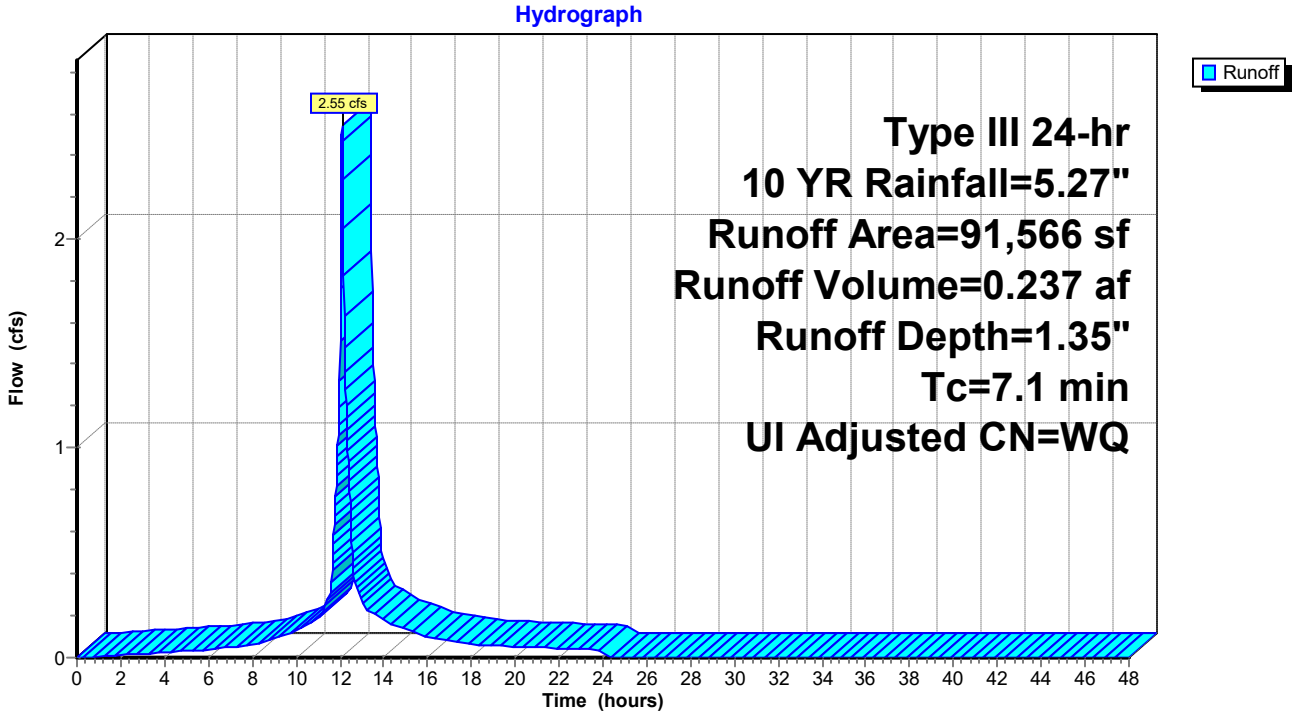
Runoff = 2.55 cfs @ 12.10 hrs, Volume= 0.237 af, Depth= 1.35"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 YR Rainfall=5.27"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 270% of capacity of segment #3

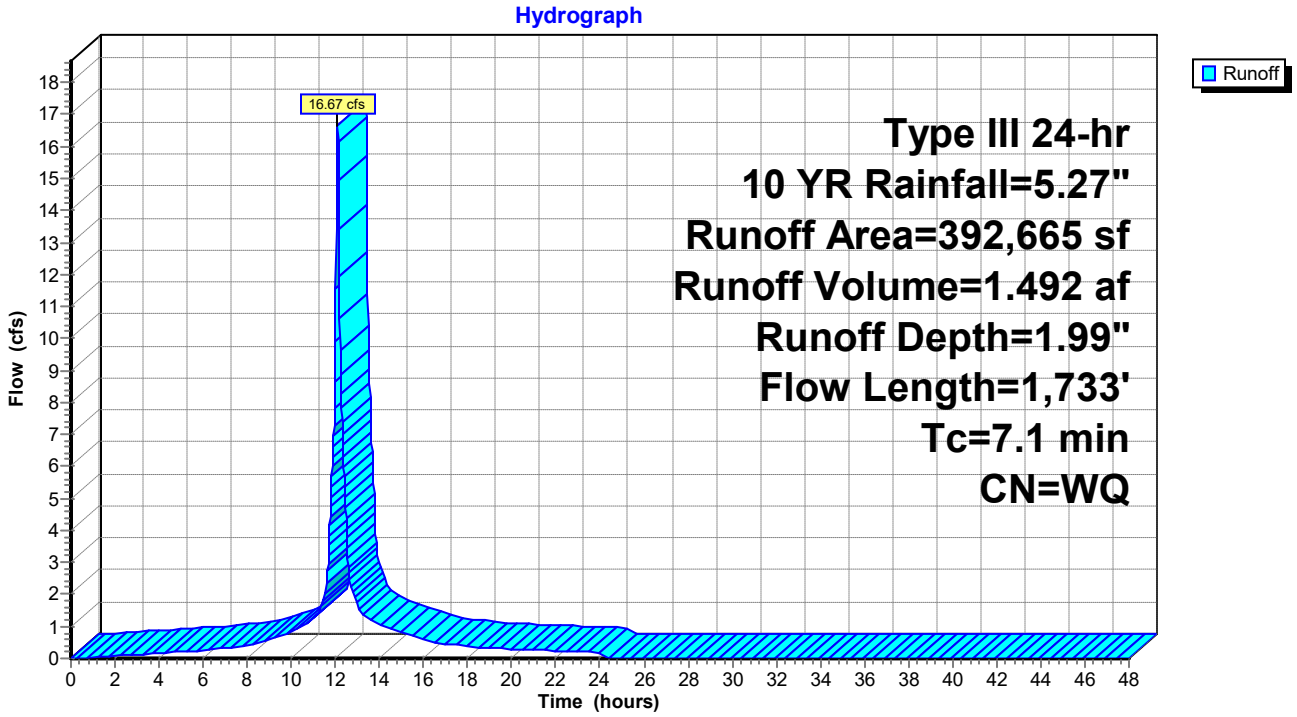
Runoff = 16.67 cfs @ 12.10 hrs, Volume= 1.492 af, Depth= 1.99"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 YR Rainfall=5.27"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



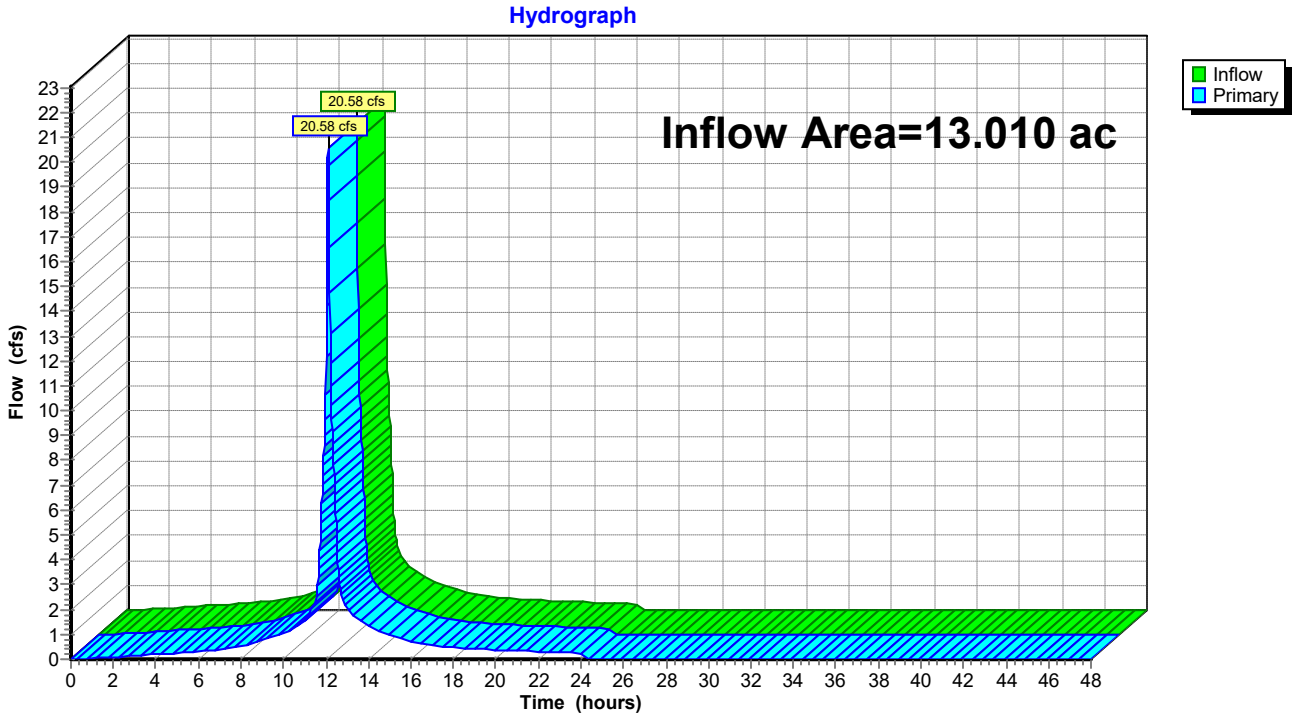
Summary for Pond 1P: Curve Hill Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 1.71" for 10 YR event
Inflow = 20.58 cfs @ 12.10 hrs, Volume= 1.859 af
Primary = 20.58 cfs @ 12.10 hrs, Volume= 1.859 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 1P: Curve Hill Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=1.17"
Tc=7.1 min CN=WQ Runoff=1.77 cfs 0.185 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=1.86"
Tc=7.1 min UI Adjusted CN=WQ Runoff=3.30 cfs 0.326 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=2.63"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=21.21 cfs 1.974 af

Pond 1P: Curve Hill Wetland Inflow=26.28 cfs 2.485 af
Primary=26.28 cfs 2.485 af

Total Runoff Area = 13.010 ac Runoff Volume = 2.485 af Average Runoff Depth = 2.29"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

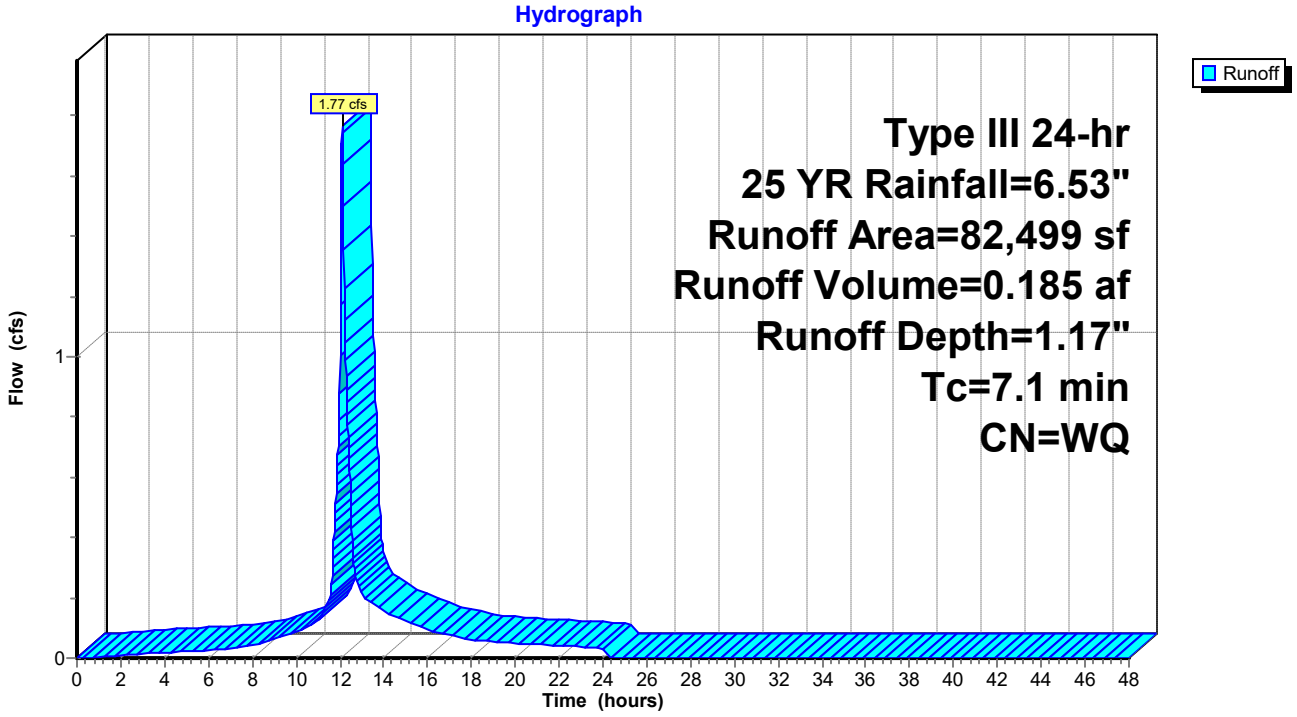
Runoff = 1.77 cfs @ 12.10 hrs, Volume= 0.185 af, Depth= 1.17"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25 YR Rainfall=6.53"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

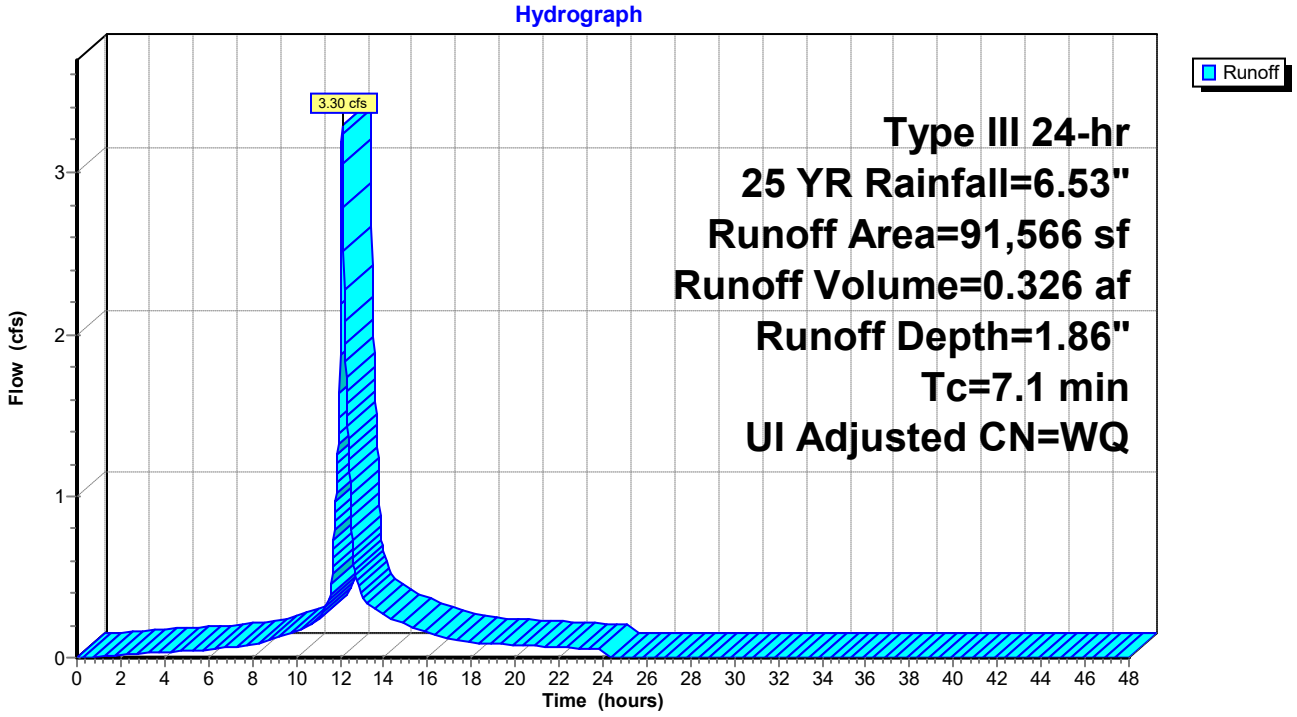
Runoff = 3.30 cfs @ 12.10 hrs, Volume= 0.326 af, Depth= 1.86"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25 YR Rainfall=6.53"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 344% of capacity of segment #3

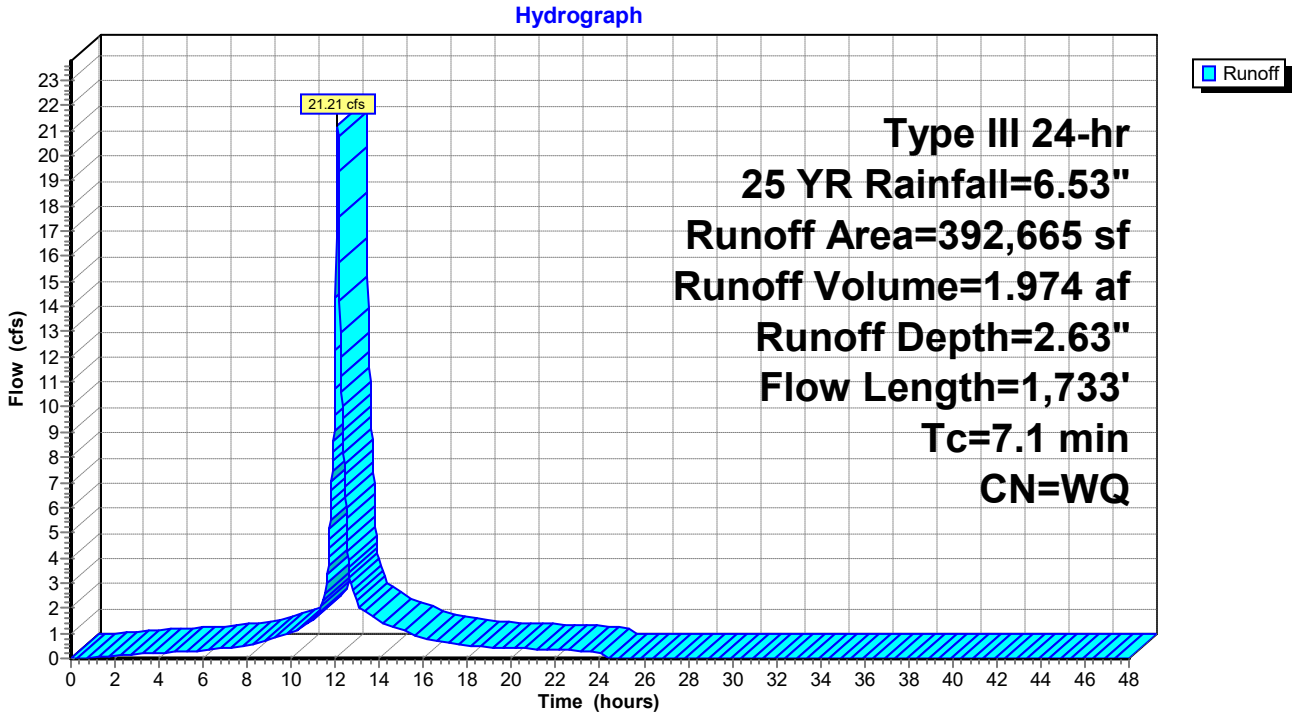
Runoff = 21.21 cfs @ 12.10 hrs, Volume= 1.974 af, Depth= 2.63"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25 YR Rainfall=6.53"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



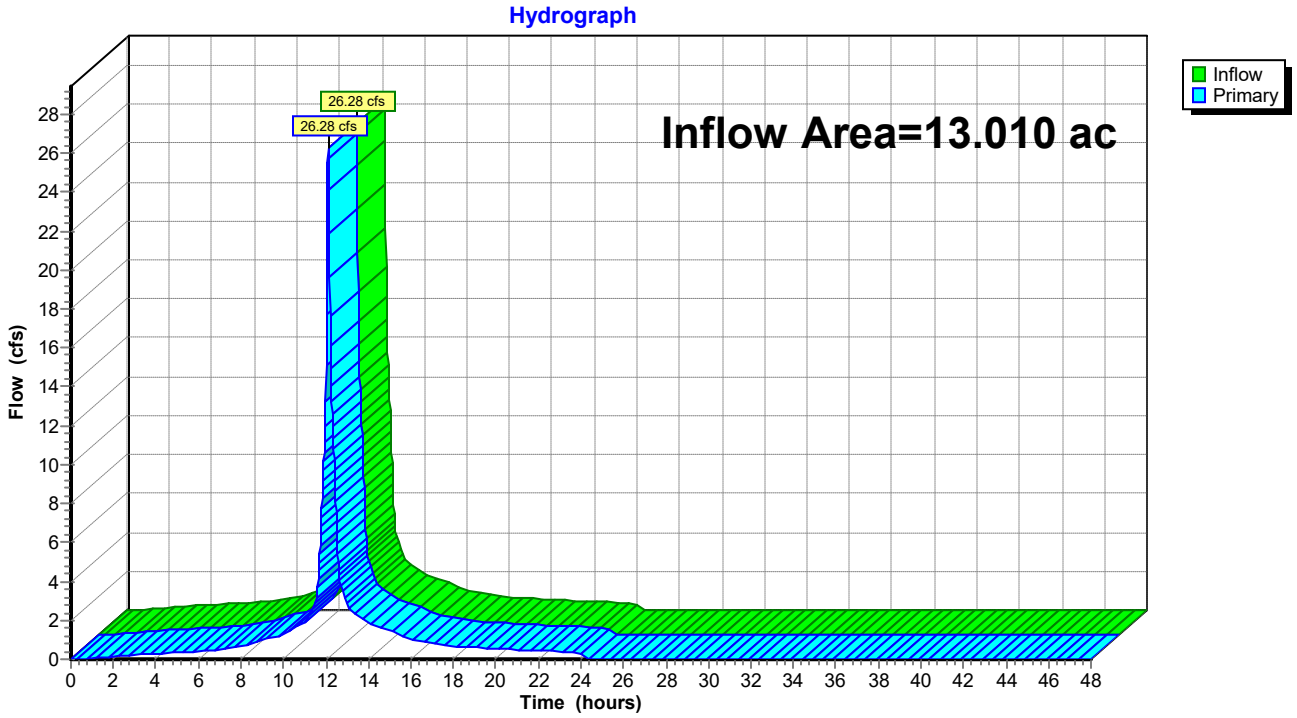
Summary for Pond 1P: Curve Hill Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 2.29" for 25 YR event
Inflow = 26.28 cfs @ 12.10 hrs, Volume= 2.485 af
Primary = 26.28 cfs @ 12.10 hrs, Volume= 2.485 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 1P: Curve Hill Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=1.95"
Tc=7.1 min CN=WQ Runoff=2.85 cfs 0.307 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=2.87"
Tc=7.1 min UI Adjusted CN=WQ Runoff=5.24 cfs 0.502 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=3.82"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=31.32 cfs 2.871 af

Pond 1P: Curve Hill Wetland Inflow=39.41 cfs 3.681 af
Primary=39.41 cfs 3.681 af

Total Runoff Area = 13.010 ac Runoff Volume = 3.681 af Average Runoff Depth = 3.39"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

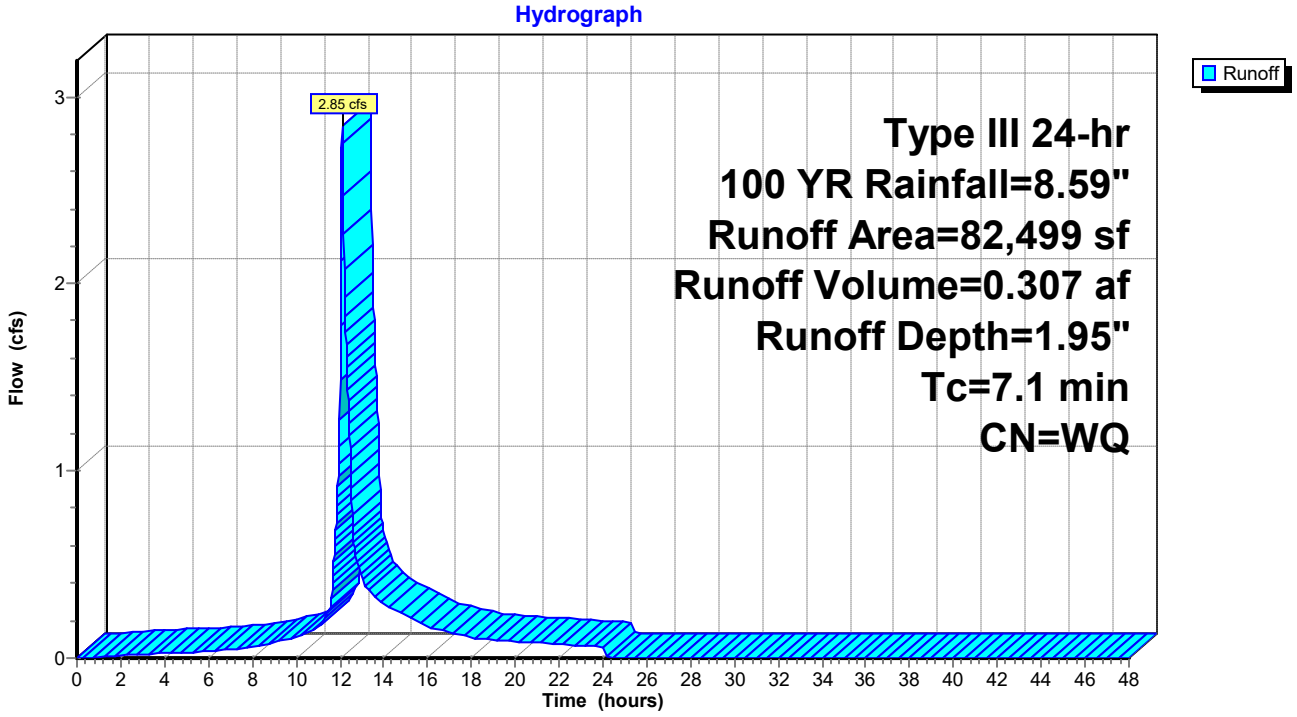
Runoff = 2.85 cfs @ 12.11 hrs, Volume= 0.307 af, Depth= 1.95"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 YR Rainfall=8.59"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

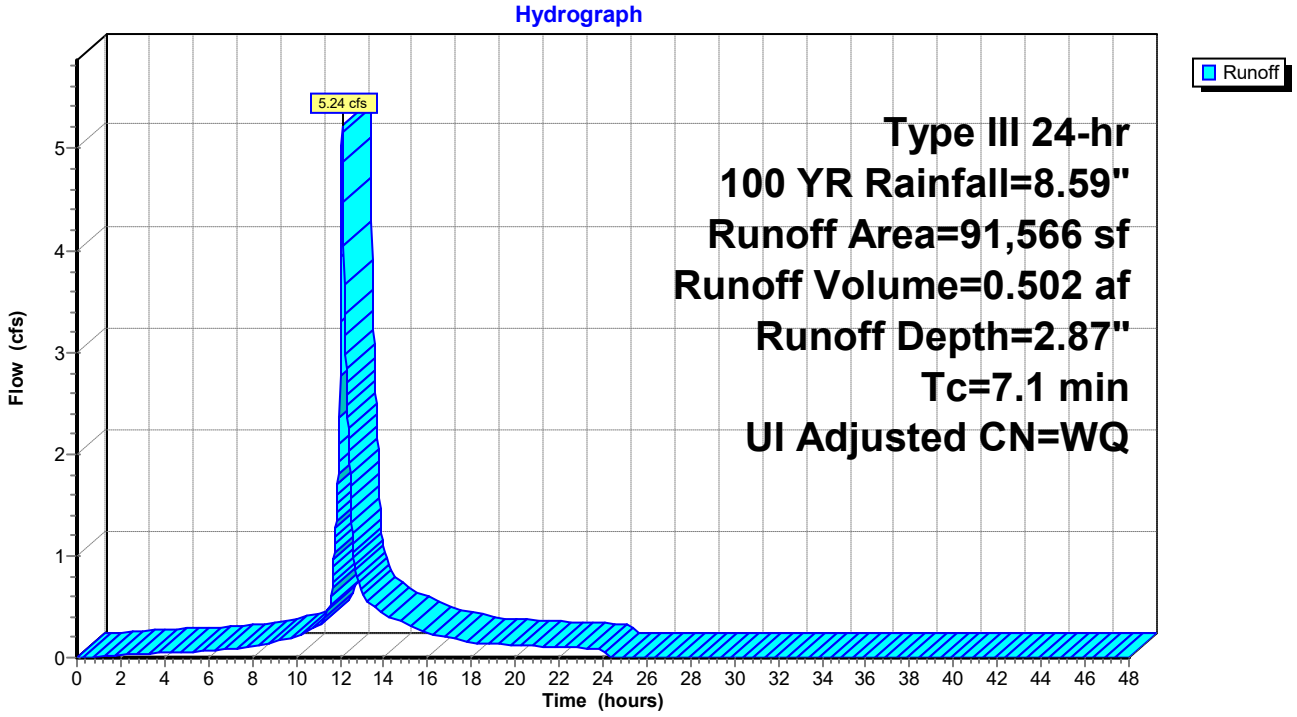
Runoff = 5.24 cfs @ 12.11 hrs, Volume= 0.502 af, Depth= 2.87"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 YR Rainfall=8.59"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 508% of capacity of segment #3

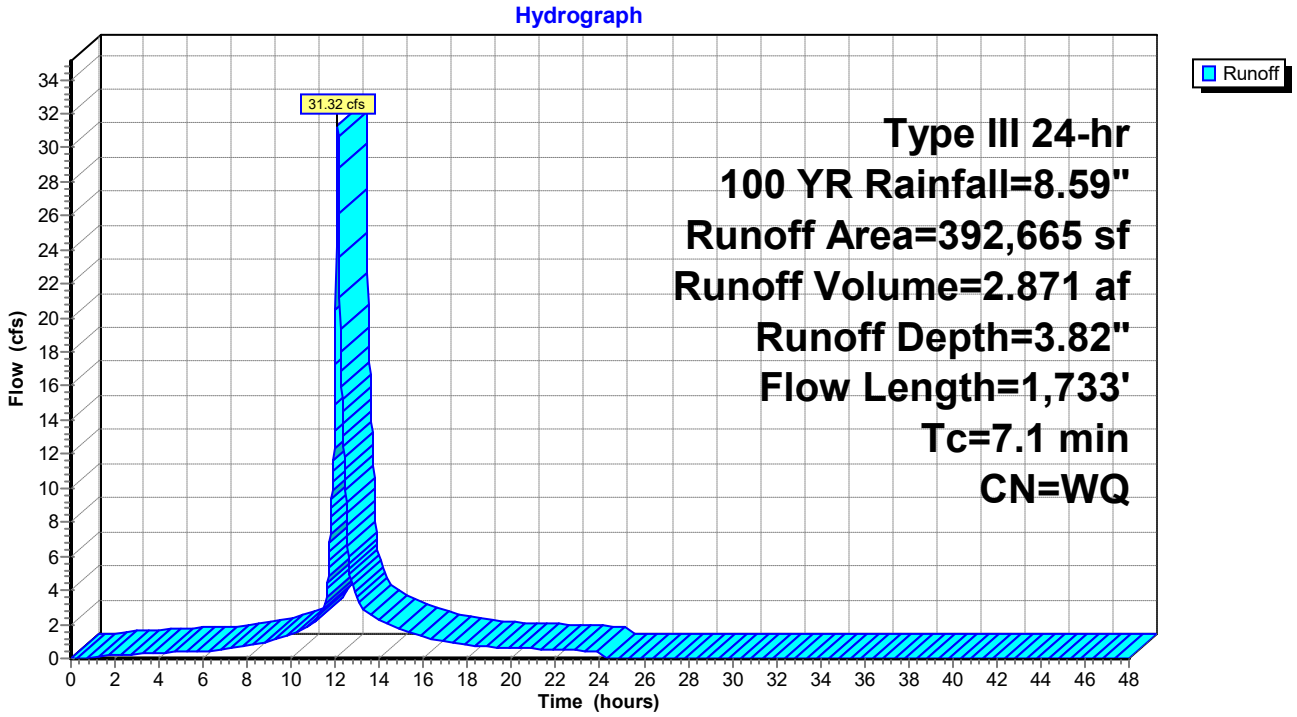
Runoff = 31.32 cfs @ 12.10 hrs, Volume= 2.871 af, Depth= 3.82"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 YR Rainfall=8.59"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



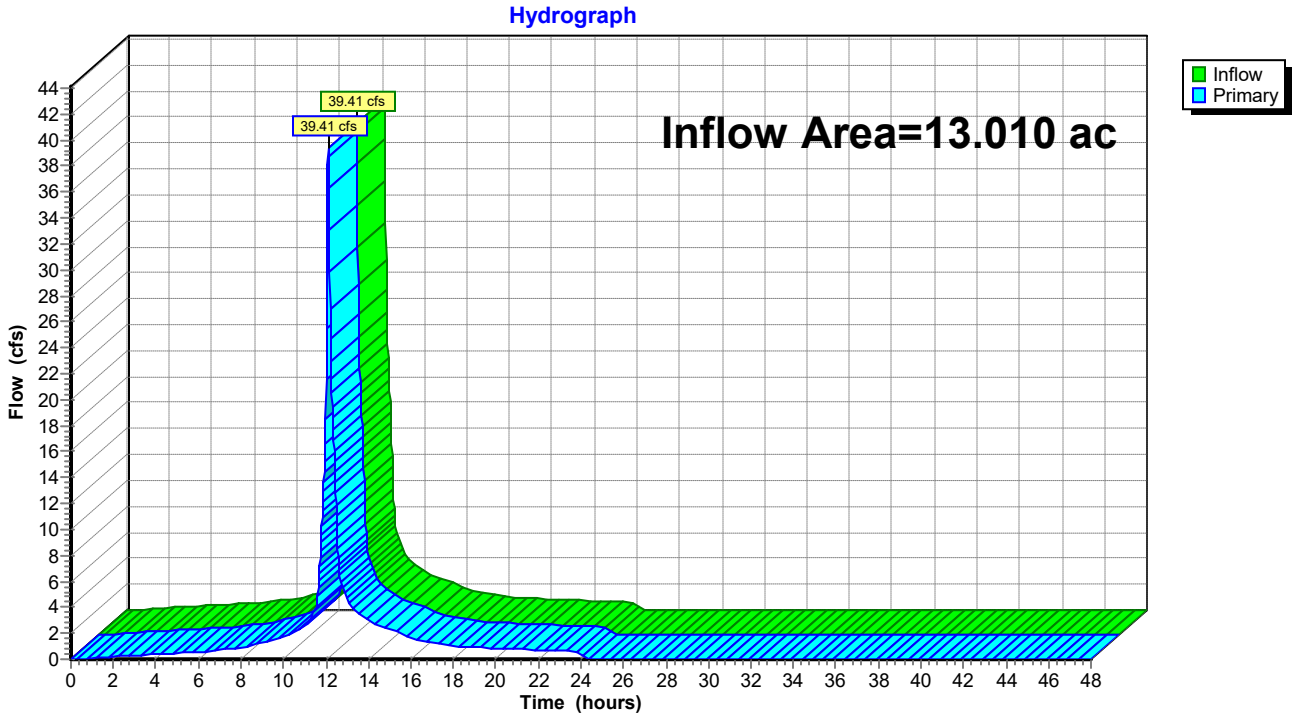
Summary for Pond 1P: Curve Hill Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 3.39" for 100 YR event
Inflow = 39.41 cfs @ 12.10 hrs, Volume= 3.681 af
Primary = 39.41 cfs @ 12.10 hrs, Volume= 3.681 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 1P: Curve Hill Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=0.14"
Tc=7.1 min CN=WQ Runoff=0.29 cfs 0.023 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=0.24"
Tc=7.1 min UI Adjusted CN=WQ Runoff=0.55 cfs 0.043 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=0.37"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=3.57 cfs 0.279 af

Pond 1P: Curve Hill Wetland Inflow=4.41 cfs 0.344 af
Primary=4.41 cfs 0.344 af

Total Runoff Area = 13.010 ac Runoff Volume = 0.344 af Average Runoff Depth = 0.32"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

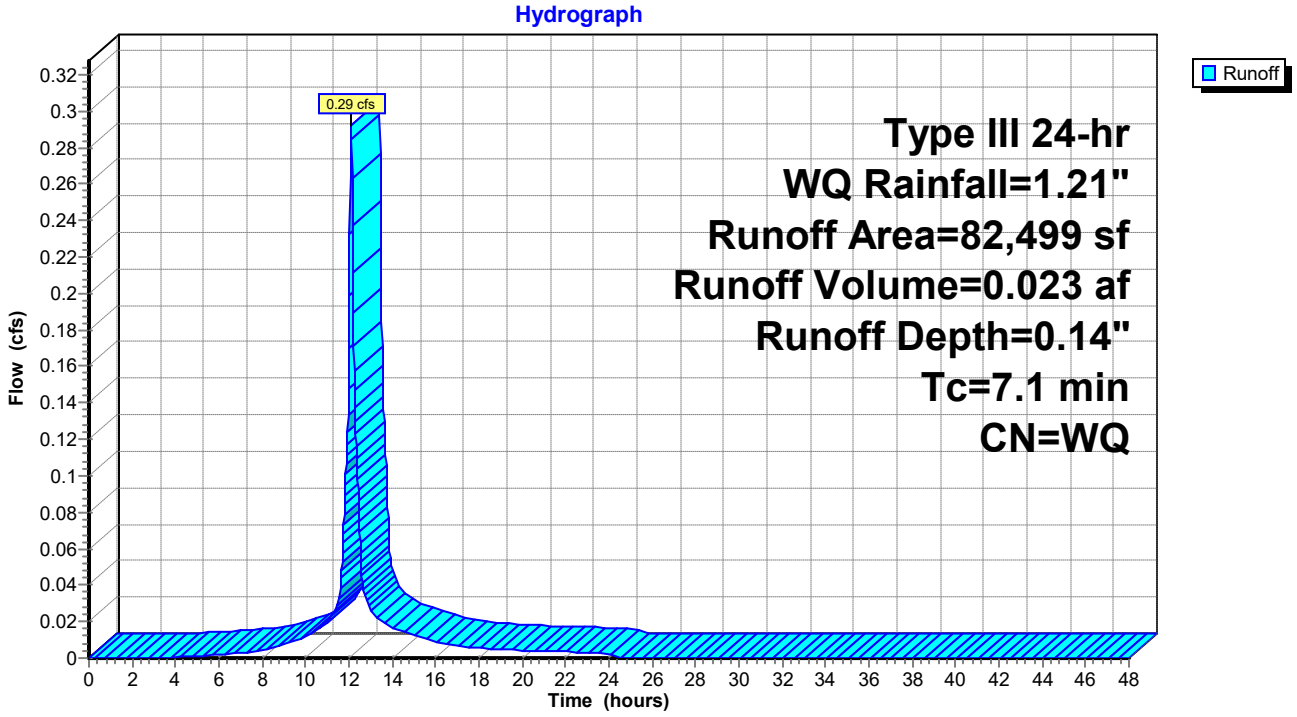
Runoff = 0.29 cfs @ 12.10 hrs, Volume= 0.023 af, Depth= 0.14"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr WQ Rainfall=1.21"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

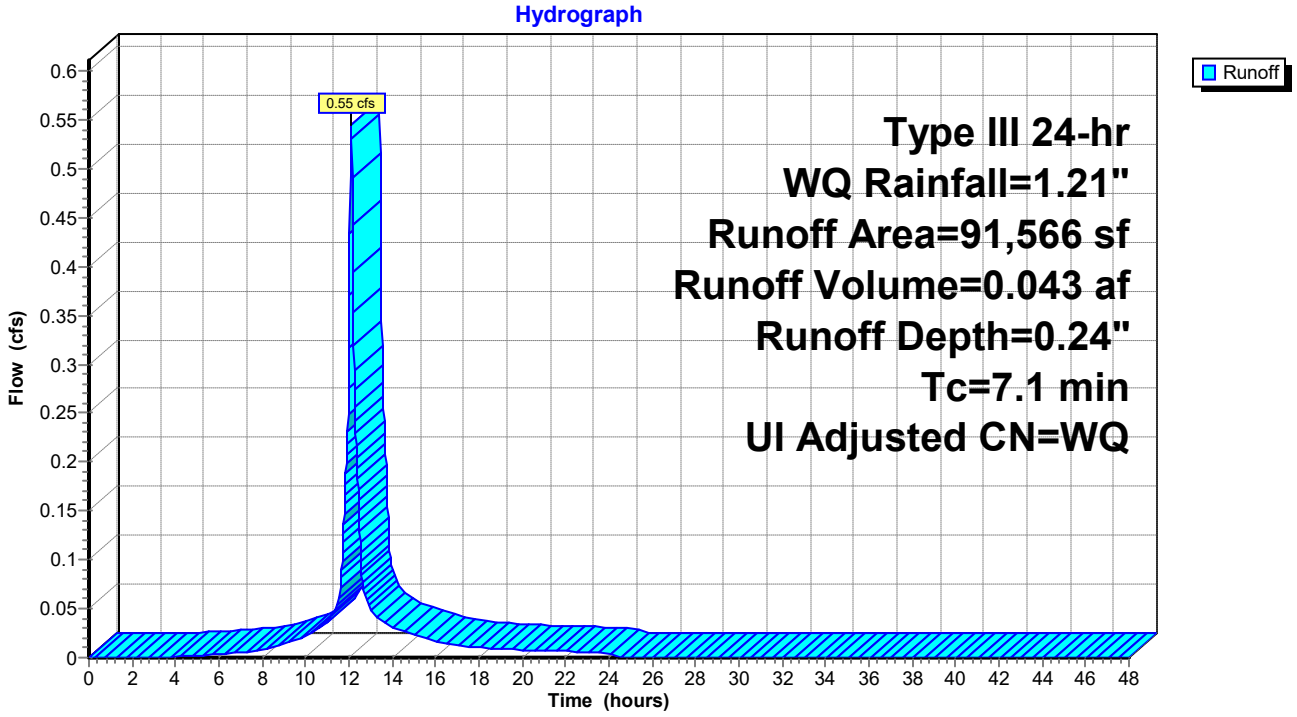
Runoff = 0.55 cfs @ 12.10 hrs, Volume= 0.043 af, Depth= 0.24"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr WQ Rainfall=1.21"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

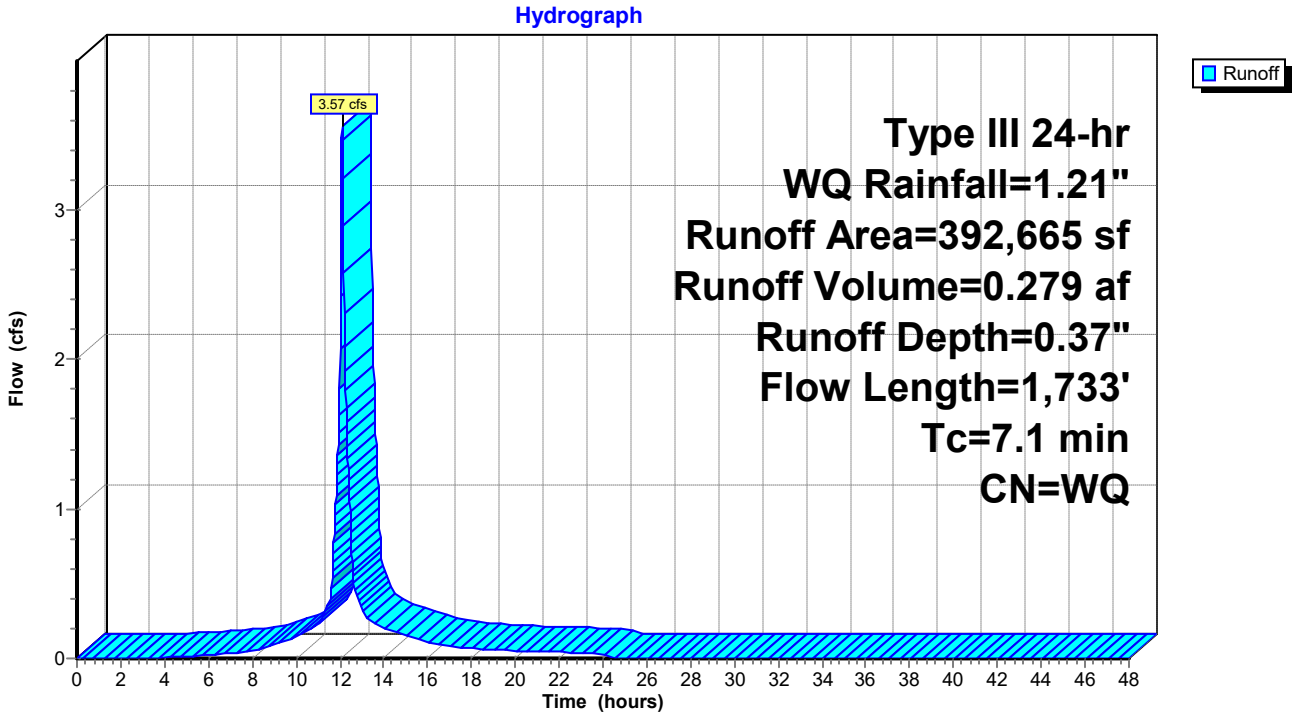
Runoff = 3.57 cfs @ 12.10 hrs, Volume= 0.279 af, Depth= 0.37"
Routed to Pond 1P : Curve Hill Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr WQ Rainfall=1.21"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



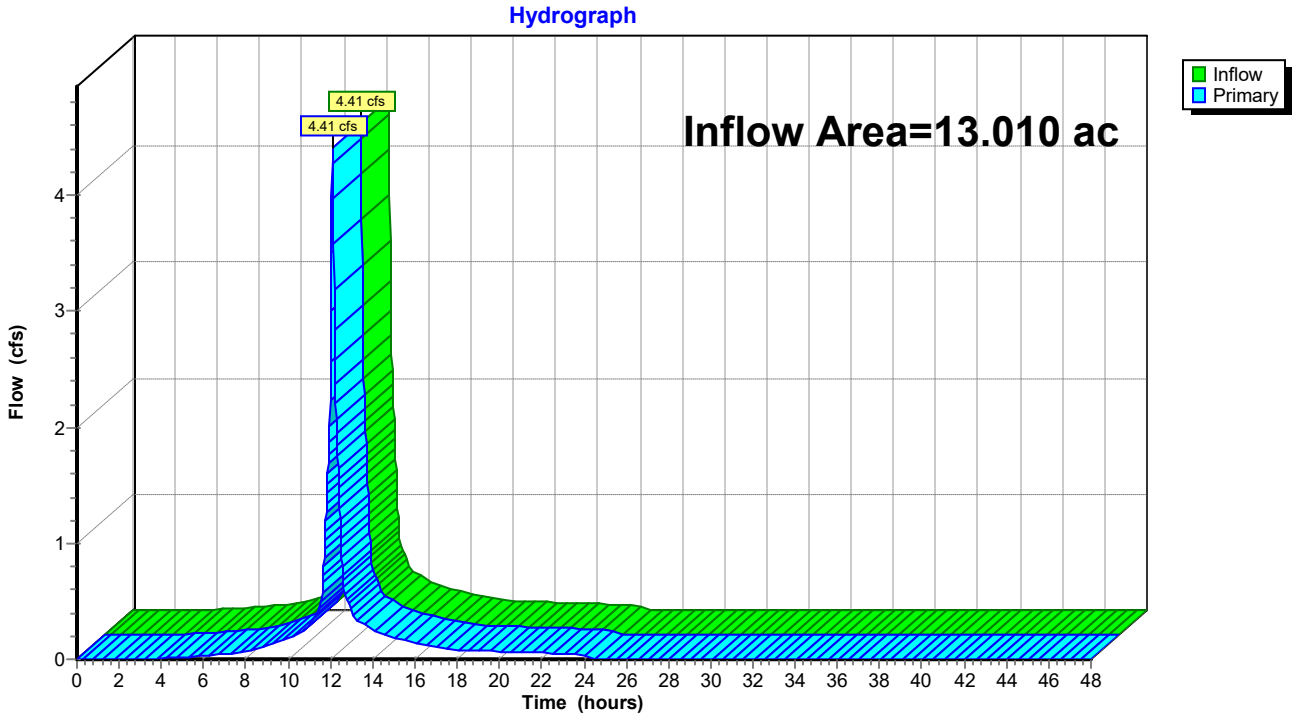
Summary for Pond 1P: Curve Hill Wetland

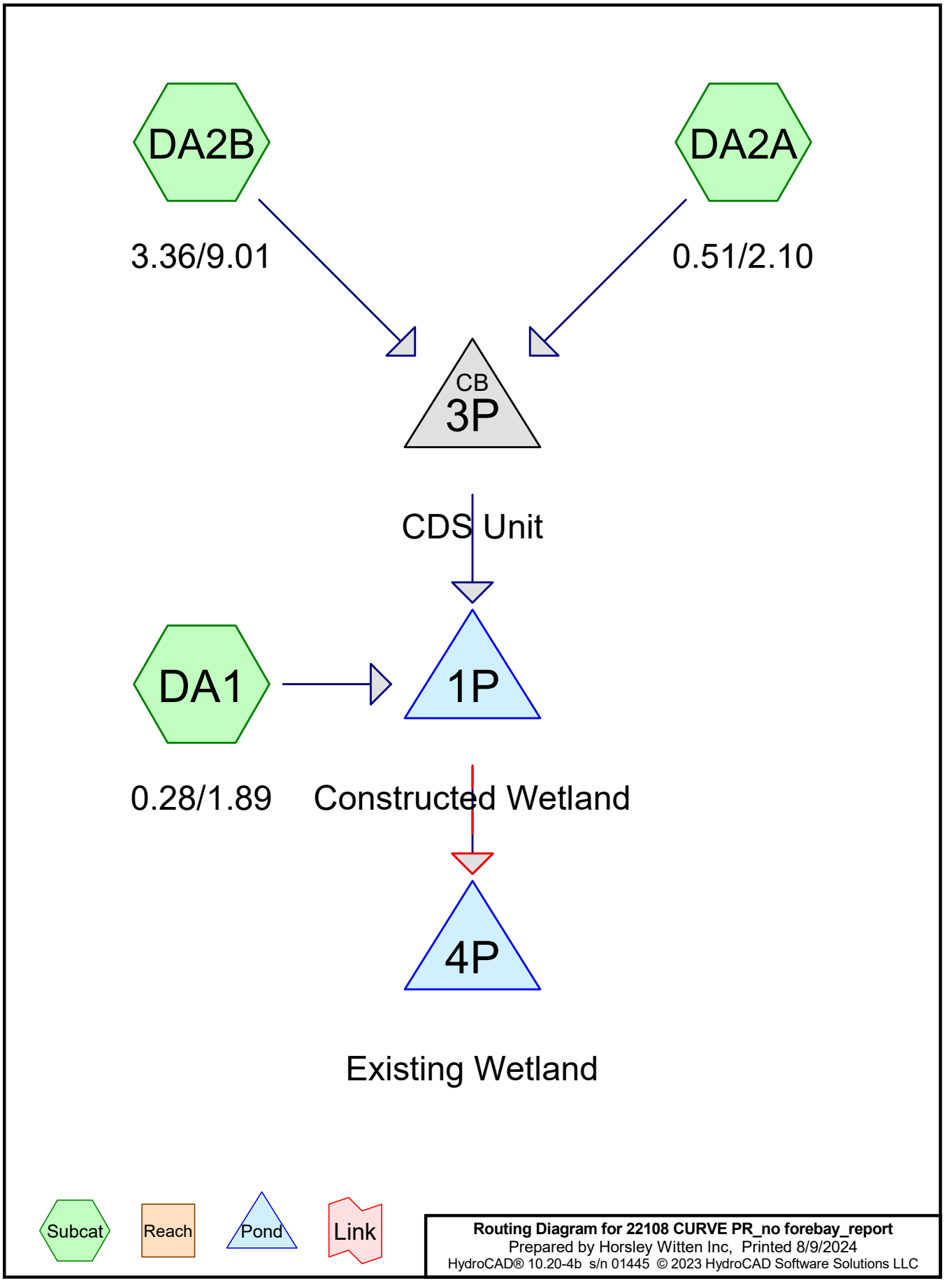
[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 0.32" for WQ event
Inflow = 4.41 cfs @ 12.10 hrs, Volume= 0.344 af
Primary = 4.41 cfs @ 12.10 hrs, Volume= 0.344 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 1P: Curve Hill Wetland





Routing Diagram for 22108 CURVE PR_no forebay_report
Prepared by Horsley Witten Inc, Printed 8/9/2024

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2 YR	Type III 24-hr		Default	24.00	1	3.60	2
2	10 YR	Type III 24-hr		Default	24.00	1	5.27	2
3	25 YR	Type III 24-hr		Default	24.00	1	6.53	2
4	100 YR	Type III 24-hr		Default	24.00	1	8.59	2
5	WQ	Type III 24-hr		Default	24.00	1	1.21	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
5.344	39	>75% Grass cover, Good, HSG A (DA1, DA2A, DA2B)
0.080	98	Paved parking, HSG A (DA1)
1.200	98	Roofs, HSG A (DA1, DA2A, DA2B)
2.858	98	Unconnected pavement, HSG A (DA2A, DA2B)
0.009	98	Water Surface, HSG A (DA2B)
3.519	30	Woods, Good, HSG A (DA1, DA2A, DA2B)
13.010	**55**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
13.010	HSG A	DA1, DA2A, DA2B
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
0.000	Other	
13.010		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
5.344	0.000	0.000	0.000	0.000	5.344	>75% Grass cover, Good	DA1, DA2A, DA2B
0.080	0.000	0.000	0.000	0.000	0.080	Paved parking	DA1
1.200	0.000	0.000	0.000	0.000	1.200	Roofs	DA1, DA2A, DA2B
2.858	0.000	0.000	0.000	0.000	2.858	Unconnected pavement	DA2A, DA2B
0.009	0.000	0.000	0.000	0.000	0.009	Water Surface	DA2B
3.519	0.000	0.000	0.000	0.000	3.519	Woods, Good	DA1, DA2A, DA2B
13.010	**0.000**	**0.000**	**0.000**	**0.000**	**13.010**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)	Node Name
1	DA2B	0.00	0.00	1,259.0	0.0300	0.013	0.0	12.0	0.0	
2	1P	4.00	4.50	43.0	-0.0116	0.013	0.0	24.0	0.0	
3	3P	7.50	7.00	36.0	0.0139	0.013	0.0	24.0	0.0	

Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=0.49"
Tc=7.1 min CN=WQ Runoff=0.93 cfs 0.078 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=0.83"
Tc=7.1 min UI Adjusted CN=WQ Runoff=1.73 cfs 0.145 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=1.26"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=11.32 cfs 0.947 af

Pond 1P: Constructed Wetland Peak Elev=8.10' Storage=17,359 cf Inflow=13.98 cfs 1.169 af
Primary=9.28 cfs 0.896 af Secondary=0.00 cfs 0.000 af Outflow=9.28 cfs 0.896 af

Pond 3P: CDS Unit Peak Elev=9.69' Inflow=13.05 cfs 1.092 af
24.0" Round Culvert n=0.013 L=36.0' S=0.0139 '/' Outflow=13.05 cfs 1.092 af

Pond 4P: Existing Wetland Inflow=9.28 cfs 0.896 af
Primary=9.28 cfs 0.896 af

Total Runoff Area = 13.010 ac Runoff Volume = 1.169 af Average Runoff Depth = 1.08"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

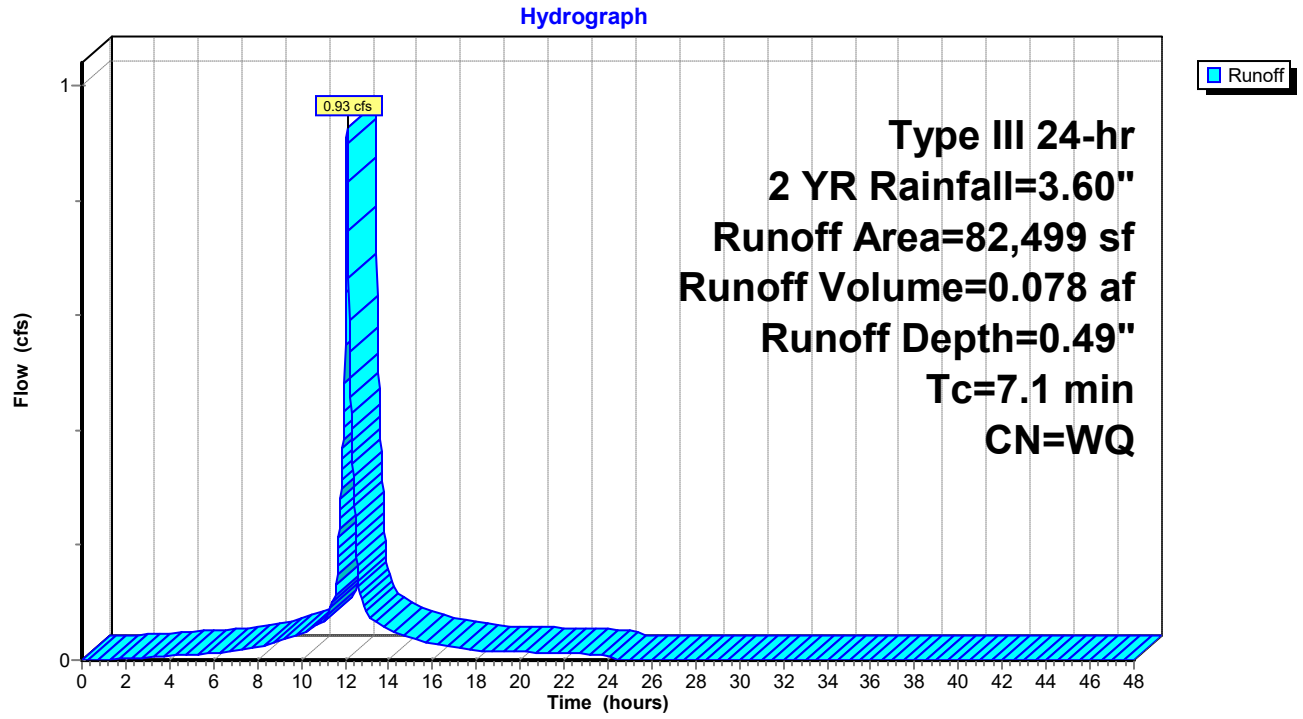
Runoff = 0.93 cfs @ 12.10 hrs, Volume= 0.078 af, Depth= 0.49"
Routed to Pond 1P : Constructed Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2 YR Rainfall=3.60"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

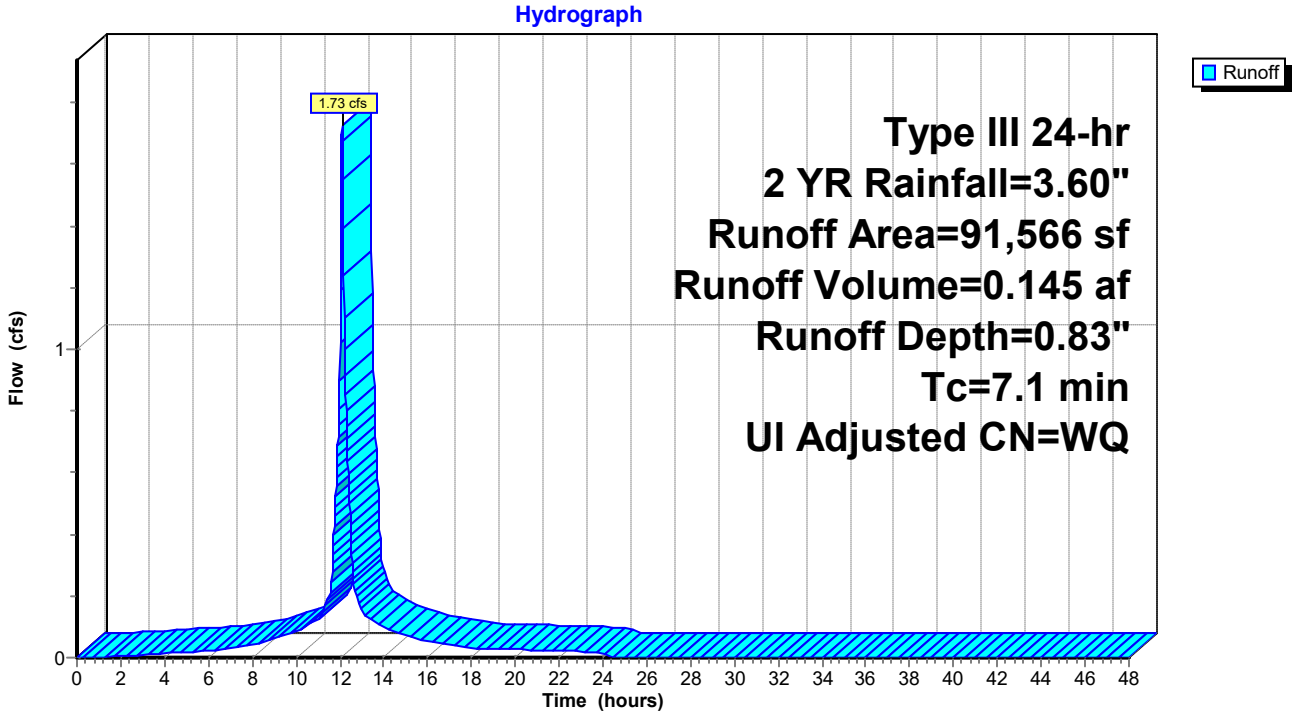
Runoff = 1.73 cfs @ 12.10 hrs, Volume= 0.145 af, Depth= 0.83"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2 YR Rainfall=3.60"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 183% of capacity of segment #3

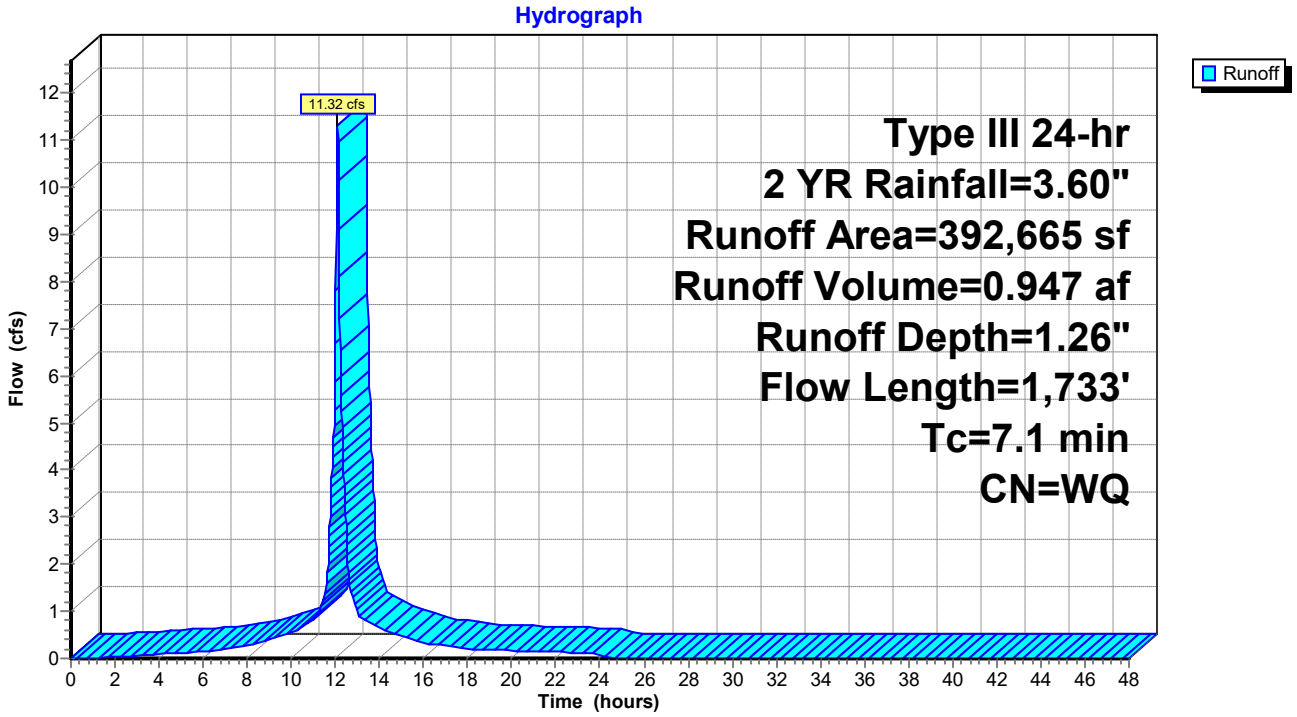
Runoff = 11.32 cfs @ 12.10 hrs, Volume= 0.947 af, Depth= 1.26"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 2 YR Rainfall=3.60"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



Summary for Pond 1P: Constructed Wetland

[81] Warning: Exceeded Pond 3P by 0.01' @ 24.40 hrs

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 1.08" for 2 YR event
Inflow = 13.98 cfs @ 12.10 hrs, Volume= 1.169 af
Outflow = 9.28 cfs @ 12.19 hrs, Volume= 0.896 af, Atten= 34%, Lag= 5.8 min
Primary = 9.28 cfs @ 12.19 hrs, Volume= 0.896 af
Routed to Pond 4P : Existing Wetland
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Pond 4P : Existing Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 8.10' @ 12.19 hrs Surf.Area= 9,490 sf Storage= 17,359 cf

Plug-Flow detention time= 166.4 min calculated for 0.895 af (77% of inflow)
Center-of-Mass det. time= 81.7 min (839.2 - 757.5)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	37,731 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

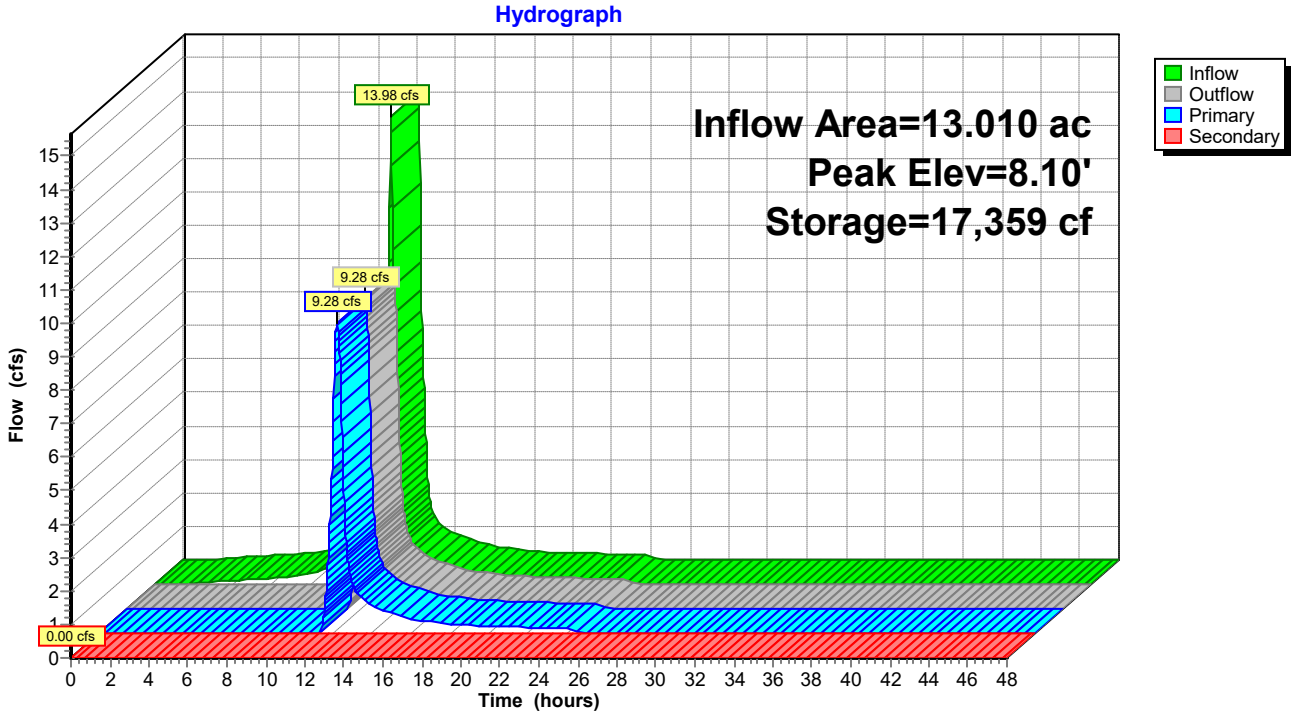
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	304	0	0
4.00	822	563	563
5.00	1,571	1,197	1,760
6.00	2,690	2,131	3,890
7.00	6,121	4,406	8,296
7.50	8,401	3,631	11,926
8.00	9,400	4,450	16,376
9.00	10,263	9,832	26,208
10.00	12,784	11,524	37,731

Device	Routing	Invert	Outlet Devices
#1	Device 2	4.50'	**24.0" Round Culvert** L= 43.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 4.00' / 4.50' S= -0.0116 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Primary	7.50'	**36.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Secondary	8.50'	**18.0' long + 4.0 '/' SideZ x 6.8' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.39 2.52 2.70 2.68 2.68 2.67 2.66 2.65 2.65 2.65 2.66 2.65 2.67 2.68 2.70 2.74 2.79

Primary OutFlow Max=9.28 cfs @ 12.19 hrs HW=8.10' (Free Discharge)
└**2=Orifice/Grate** (Passes 9.28 cfs of 14.44 cfs potential flow)
└**1=Culvert** (Inlet Controls 9.28 cfs @ 2.95 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=3.00' (Free Discharge)
└**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 1P: Constructed Wetland



Summary for Pond 3P: CDS Unit

[57] Hint: Peaked at 9.69' (Flood elevation advised)

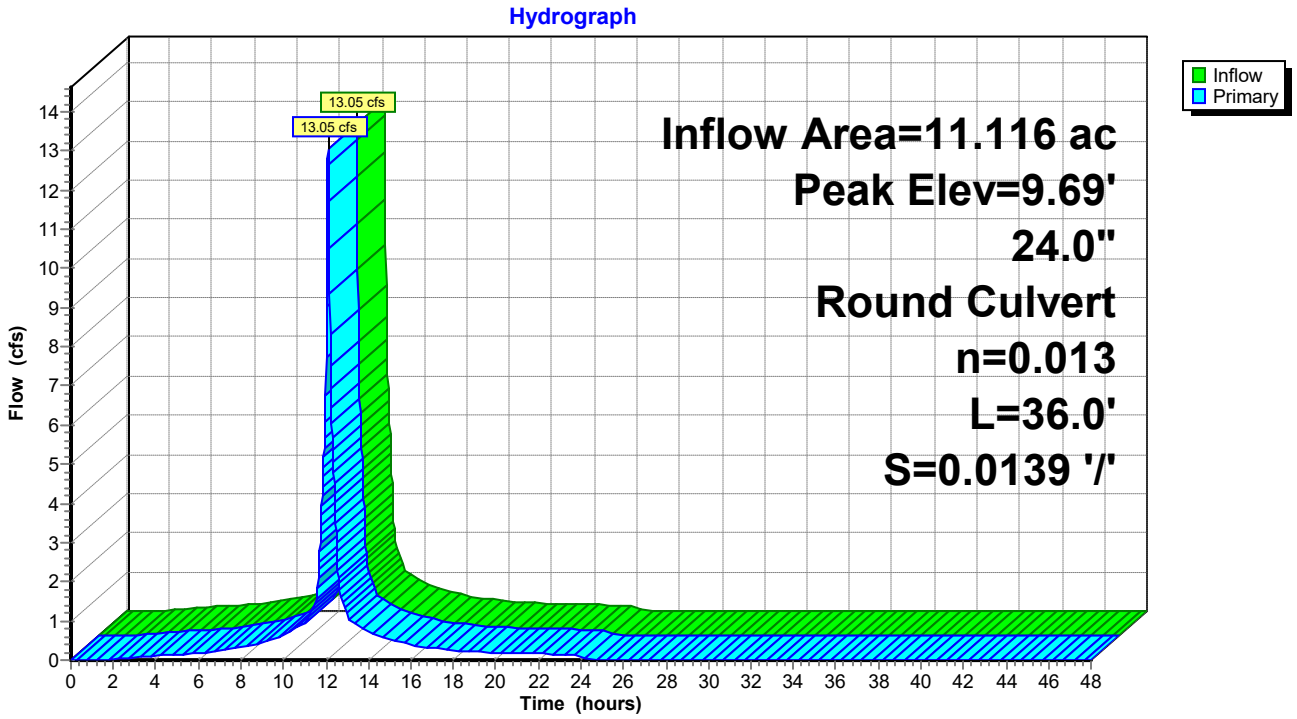
Inflow Area = 11.116 ac, 34.83% Impervious, Inflow Depth = 1.18" for 2 YR event
Inflow = 13.05 cfs @ 12.10 hrs, Volume= 1.092 af
Outflow = 13.05 cfs @ 12.10 hrs, Volume= 1.092 af, Atten= 0%, Lag= 0.0 min
Primary = 13.05 cfs @ 12.10 hrs, Volume= 1.092 af
Routed to Pond 1P : Constructed Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 9.69' @ 12.10 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	7.50'	**24.0" Round Culvert** L= 36.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 7.50' / 7.00' S= 0.0139 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=13.02 cfs @ 12.10 hrs HW=9.69' TW=7.50' (Fixed TW Elev= 7.50')
1=Culvert (Inlet Controls 13.02 cfs @ 4.14 fps)

Pond 3P: CDS Unit



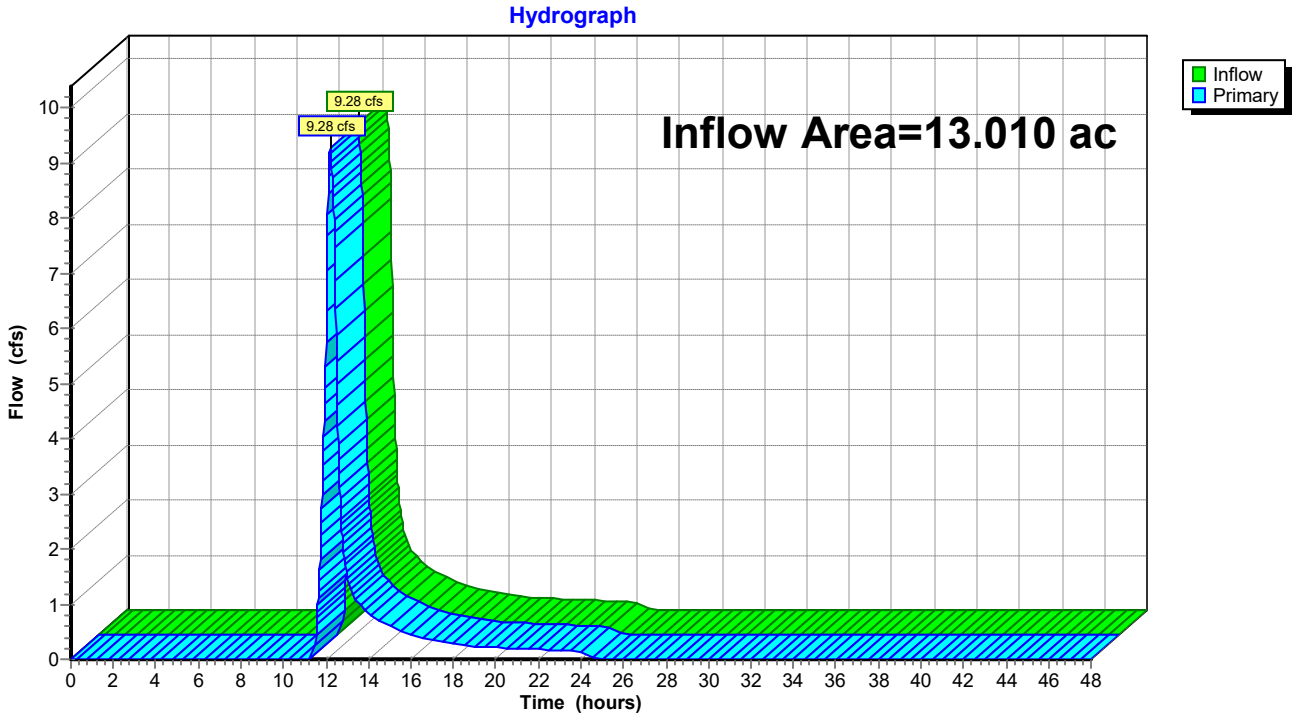
Summary for Pond 4P: Existing Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 0.83" for 2 YR event
Inflow = 9.28 cfs @ 12.19 hrs, Volume= 0.896 af
Primary = 9.28 cfs @ 12.19 hrs, Volume= 0.896 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 4P: Existing Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=0.82"
Tc=7.1 min CN=WQ Runoff=1.37 cfs 0.129 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=1.35"
Tc=7.1 min UI Adjusted CN=WQ Runoff=2.55 cfs 0.237 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=1.99"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=16.67 cfs 1.492 af

Pond 1P: Constructed Wetland Peak Elev=8.48' Storage=21,007 cf Inflow=20.58 cfs 1.859 af
Primary=11.83 cfs 1.585 af Secondary=0.00 cfs 0.000 af Outflow=11.83 cfs 1.585 af

Pond 3P: CDS Unit Peak Elev=11.09' Inflow=19.21 cfs 1.730 af
24.0" Round Culvert n=0.013 L=36.0' S=0.0139 '/' Outflow=19.21 cfs 1.730 af

Pond 4P: Existing Wetland Inflow=11.83 cfs 1.585 af
Primary=11.83 cfs 1.585 af

Total Runoff Area = 13.010 ac Runoff Volume = 1.859 af Average Runoff Depth = 1.71"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

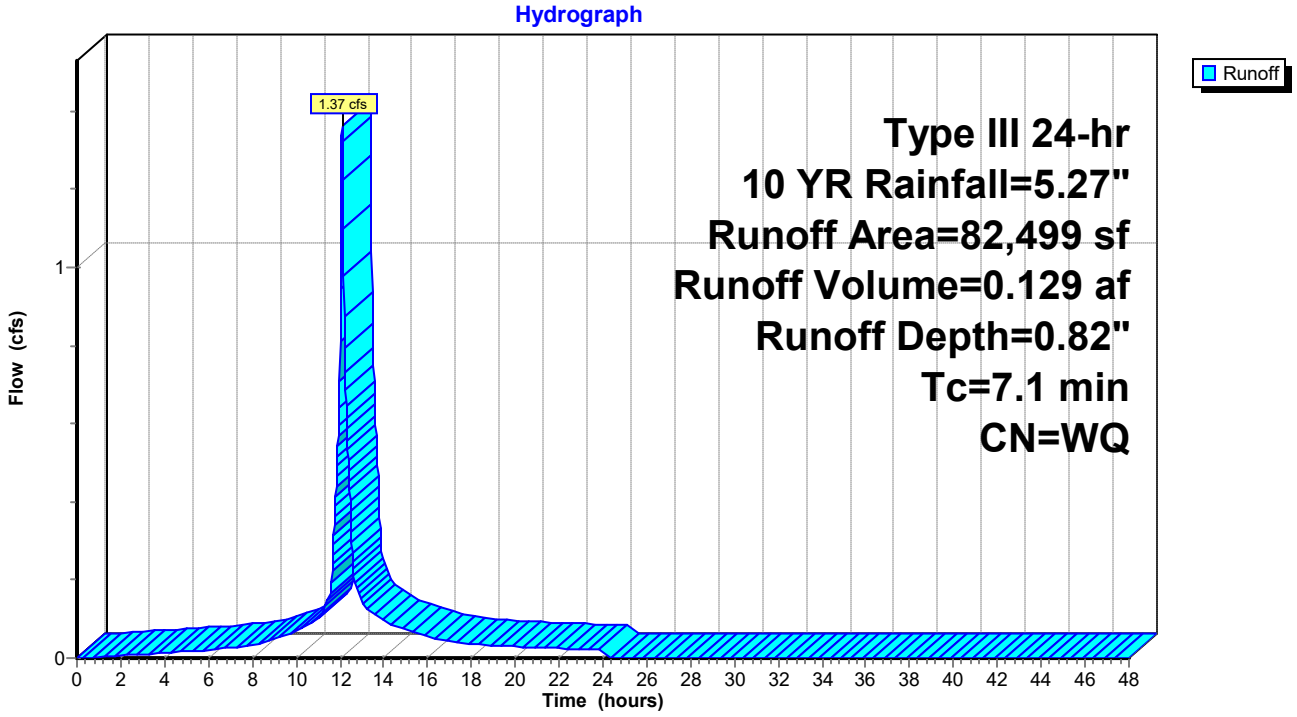
Runoff = 1.37 cfs @ 12.10 hrs, Volume= 0.129 af, Depth= 0.82"
Routed to Pond 1P : Constructed Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 YR Rainfall=5.27"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

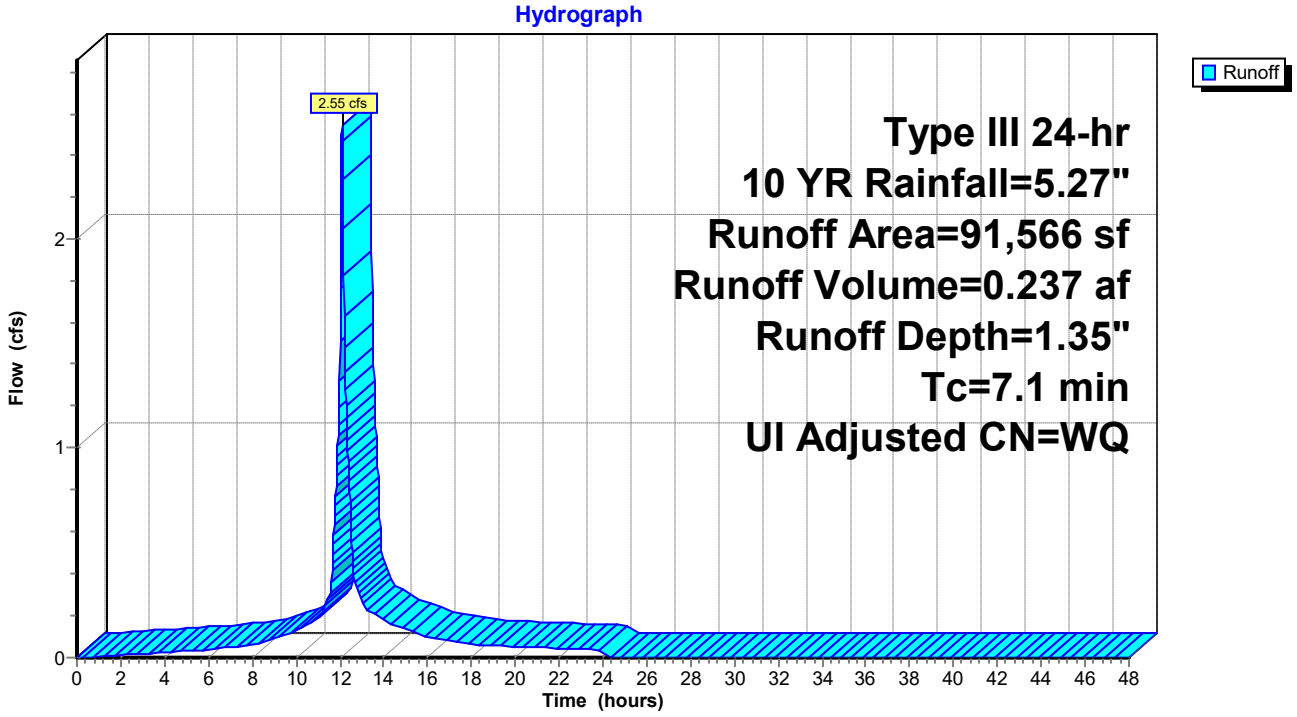
Runoff = 2.55 cfs @ 12.10 hrs, Volume= 0.237 af, Depth= 1.35"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 YR Rainfall=5.27"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 270% of capacity of segment #3

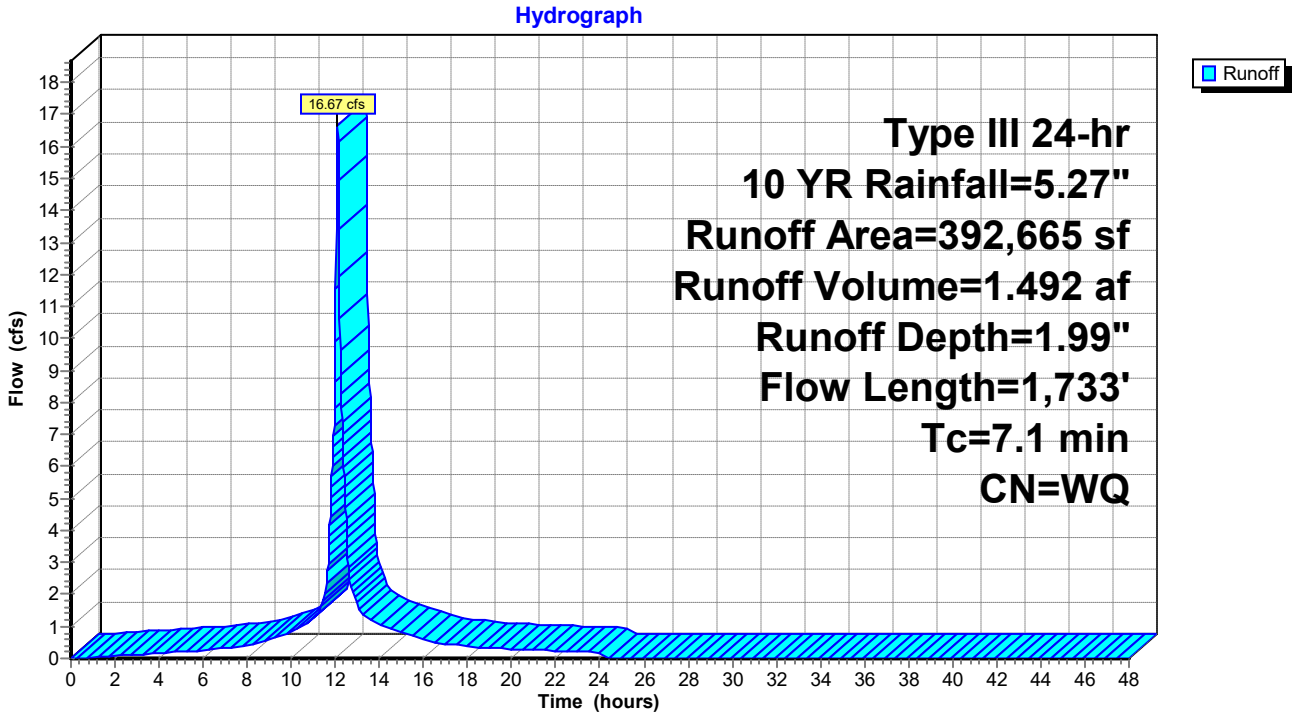
Runoff = 16.67 cfs @ 12.10 hrs, Volume= 1.492 af, Depth= 1.99"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 10 YR Rainfall=5.27"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



Summary for Pond 1P: Constructed Wetland

[81] Warning: Exceeded Pond 3P by 0.02' @ 24.40 hrs

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 1.71" for 10 YR event
Inflow = 20.58 cfs @ 12.10 hrs, Volume= 1.859 af
Outflow = 11.83 cfs @ 12.22 hrs, Volume= 1.585 af, Atten= 42%, Lag= 7.5 min
Primary = 11.83 cfs @ 12.22 hrs, Volume= 1.585 af
Routed to Pond 4P : Existing Wetland
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Pond 4P : Existing Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 8.48' @ 12.22 hrs Surf.Area= 9,816 sf Storage= 21,007 cf

Plug-Flow detention time= 136.7 min calculated for 1.585 af (85% of inflow)
Center-of-Mass det. time= 68.1 min (832.6 - 764.6)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	37,731 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

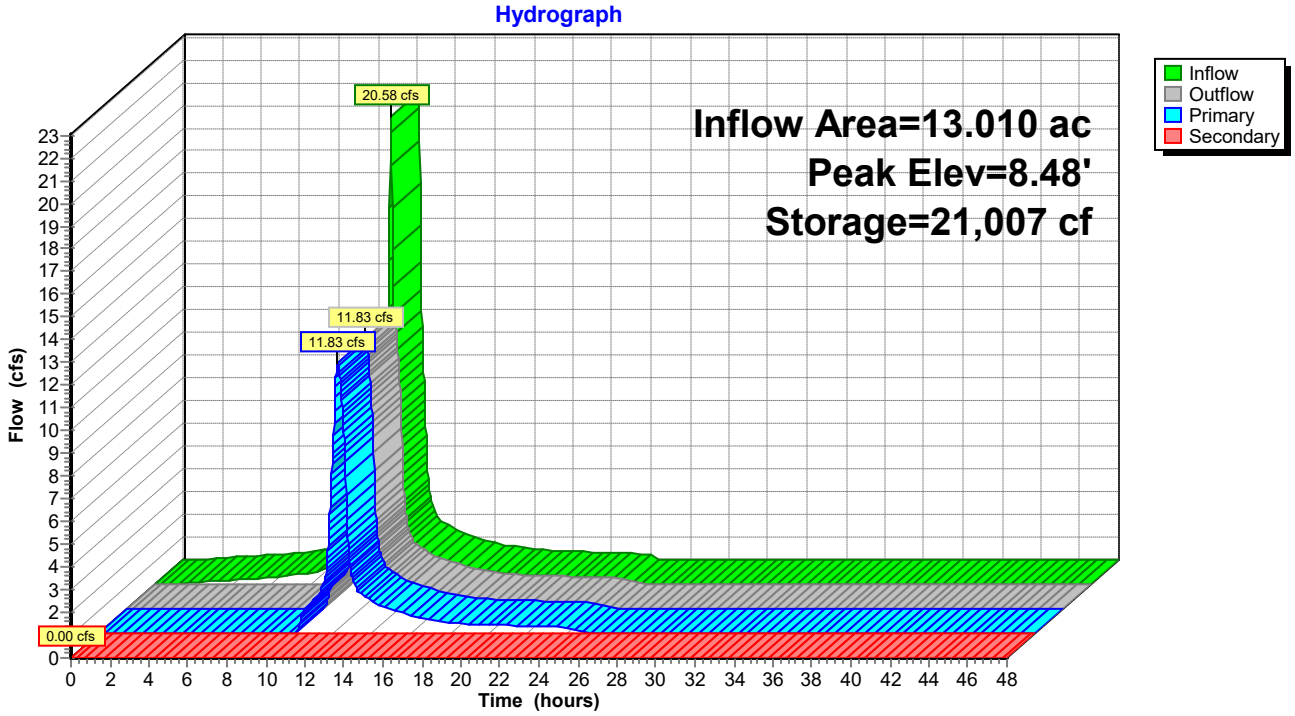
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	304	0	0
4.00	822	563	563
5.00	1,571	1,197	1,760
6.00	2,690	2,131	3,890
7.00	6,121	4,406	8,296
7.50	8,401	3,631	11,926
8.00	9,400	4,450	16,376
9.00	10,263	9,832	26,208
10.00	12,784	11,524	37,731

Device	Routing	Invert	Outlet Devices
#1	Device 2	4.50'	**24.0" Round Culvert** L= 43.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 4.00' / 4.50' S= -0.0116 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Primary	7.50'	**36.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Secondary	8.50'	**18.0' long + 4.0 '/' SideZ x 6.8' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.39 2.52 2.70 2.68 2.68 2.67 2.66 2.65 2.65 2.65 2.66 2.65 2.67 2.68 2.70 2.74 2.79

Primary OutFlow Max=11.83 cfs @ 12.22 hrs HW=8.48' (Free Discharge)
└**2=Orifice/Grate** (Passes 11.83 cfs of 29.97 cfs potential flow)
└**1=Culvert** (Inlet Controls 11.83 cfs @ 3.77 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=3.00' (Free Discharge)
└**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 1P: Constructed Wetland



Summary for Pond 3P: CDS Unit

[57] Hint: Peaked at 11.09' (Flood elevation advised)

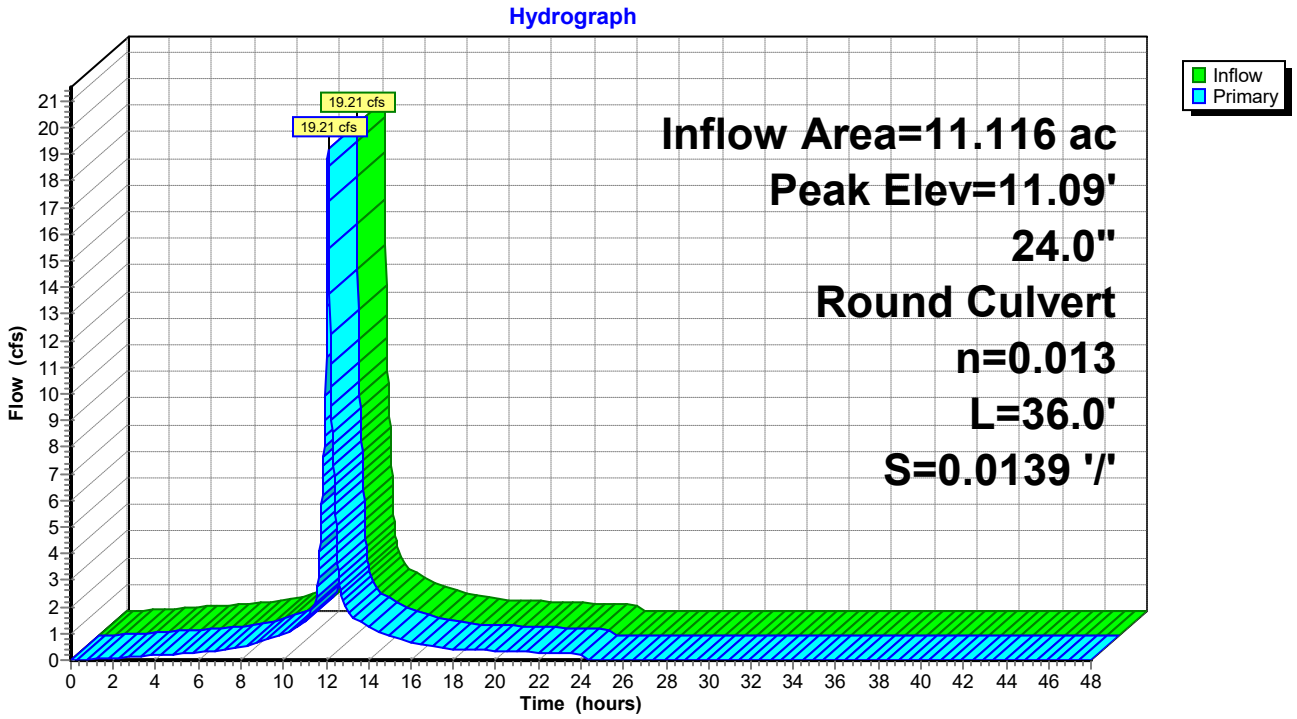
Inflow Area = 11.116 ac, 34.83% Impervious, Inflow Depth = 1.87" for 10 YR event
Inflow = 19.21 cfs @ 12.10 hrs, Volume= 1.730 af
Outflow = 19.21 cfs @ 12.10 hrs, Volume= 1.730 af, Atten= 0%, Lag= 0.0 min
Primary = 19.21 cfs @ 12.10 hrs, Volume= 1.730 af
Routed to Pond 1P : Constructed Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 11.09' @ 12.10 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	7.50'	**24.0" Round Culvert** L= 36.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 7.50' / 7.00' S= 0.0139 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=19.16 cfs @ 12.10 hrs HW=11.07' TW=7.50' (Fixed TW Elev= 7.50')
1=Culvert (Inlet Controls 19.16 cfs @ 6.10 fps)

Pond 3P: CDS Unit



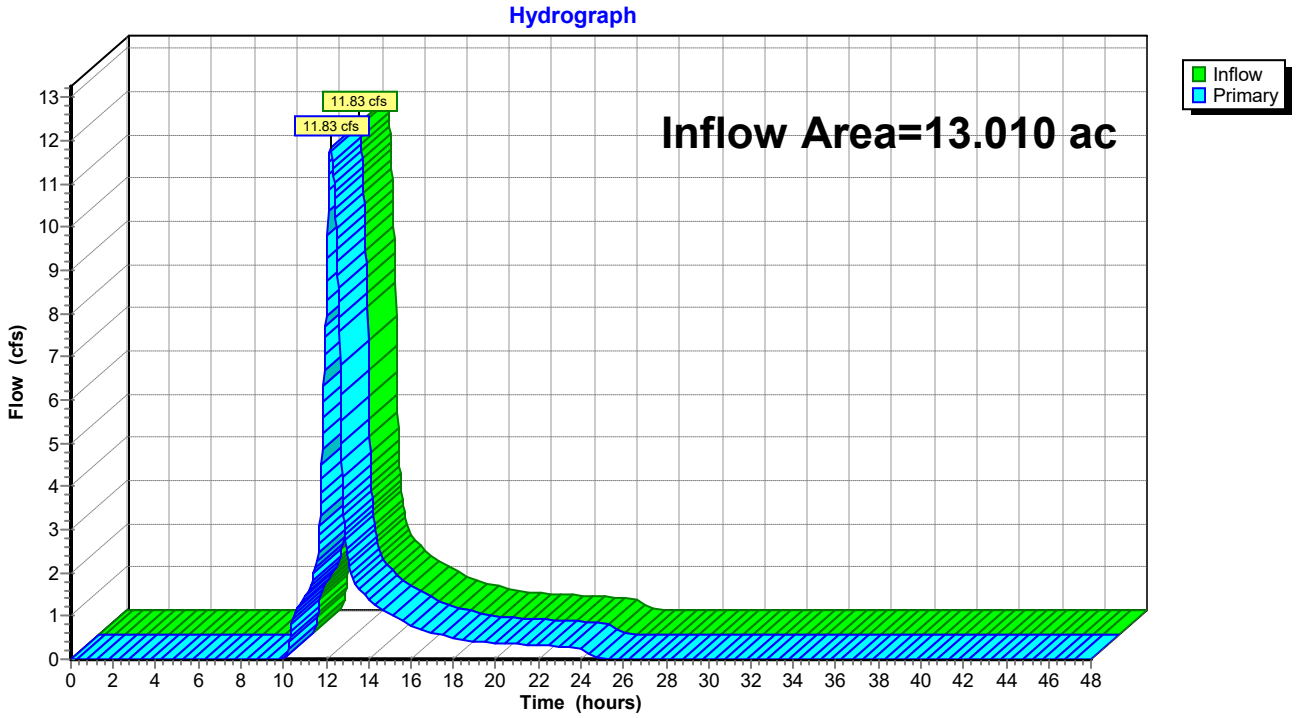
Summary for Pond 4P: Existing Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 1.46" for 10 YR event
Inflow = 11.83 cfs @ 12.22 hrs, Volume= 1.585 af
Primary = 11.83 cfs @ 12.22 hrs, Volume= 1.585 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 4P: Existing Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=1.17"
Tc=7.1 min CN=WQ Runoff=1.77 cfs 0.185 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=1.86"
Tc=7.1 min UI Adjusted CN=WQ Runoff=3.30 cfs 0.326 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=2.63"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=21.21 cfs 1.974 af

Pond 1P: Constructed Wetland Peak Elev=8.73' Storage=23,450 cf Inflow=26.28 cfs 2.485 af
Primary=13.23 cfs 2.142 af Secondary=4.96 cfs 0.070 af Outflow=18.19 cfs 2.211 af

Pond 3P: CDS Unit Peak Elev=12.71' Inflow=24.51 cfs 2.300 af
24.0" Round Culvert n=0.013 L=36.0' S=0.0139 '/' Outflow=24.51 cfs 2.300 af

Pond 4P: Existing Wetland Inflow=18.19 cfs 2.211 af
Primary=18.19 cfs 2.211 af

Total Runoff Area = 13.010 ac Runoff Volume = 2.485 af Average Runoff Depth = 2.29"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

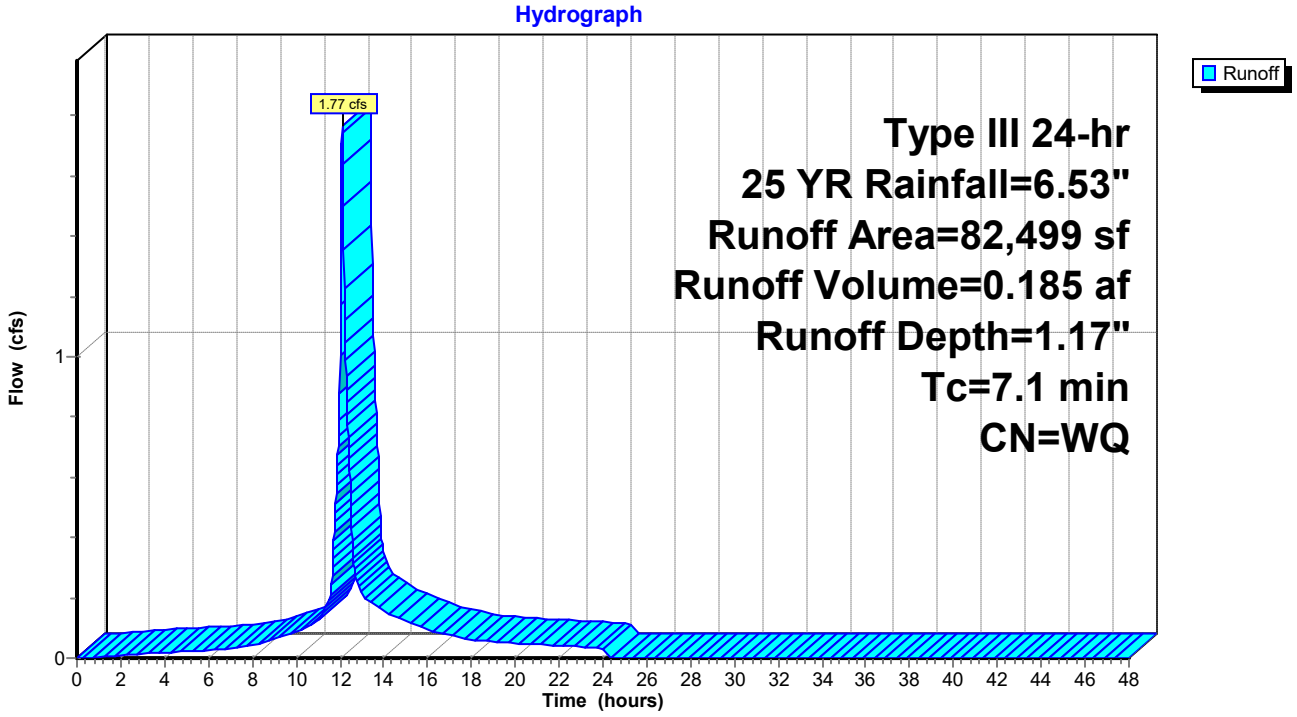
Runoff = 1.77 cfs @ 12.10 hrs, Volume= 0.185 af, Depth= 1.17"
Routed to Pond 1P : Constructed Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25 YR Rainfall=6.53"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

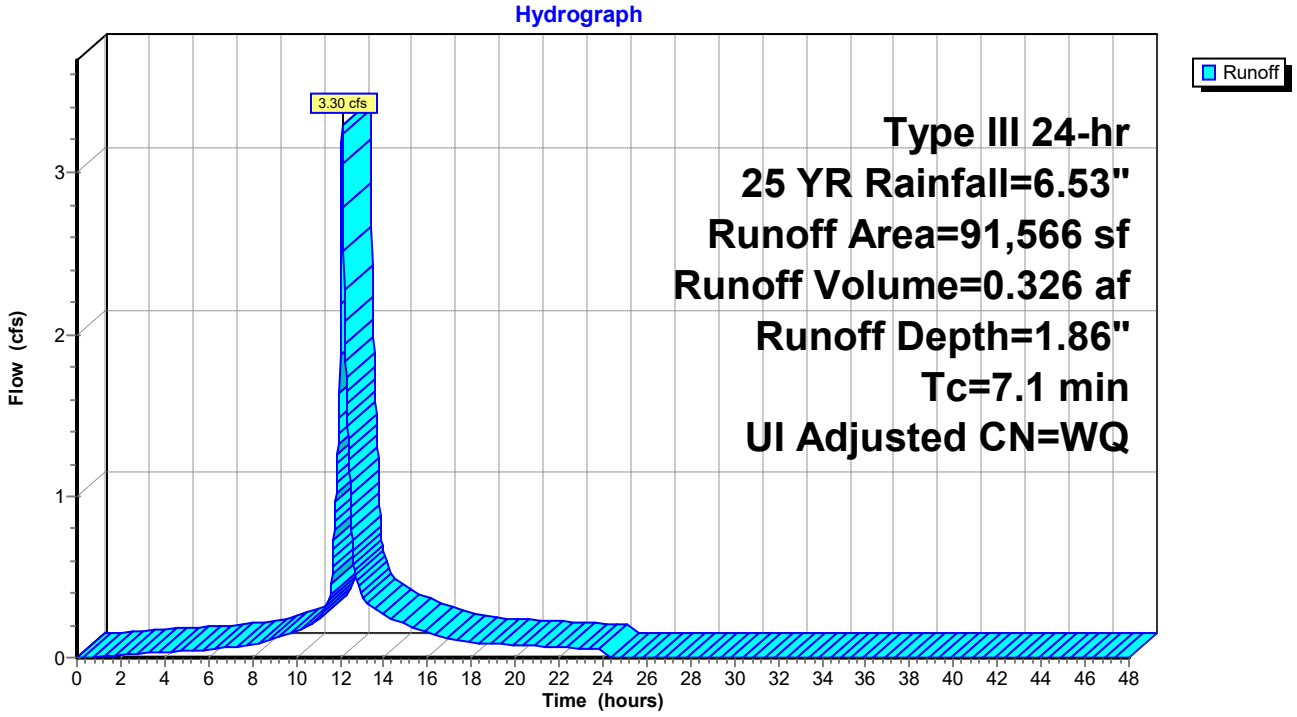
Runoff = 3.30 cfs @ 12.10 hrs, Volume= 0.326 af, Depth= 1.86"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25 YR Rainfall=6.53"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 344% of capacity of segment #3

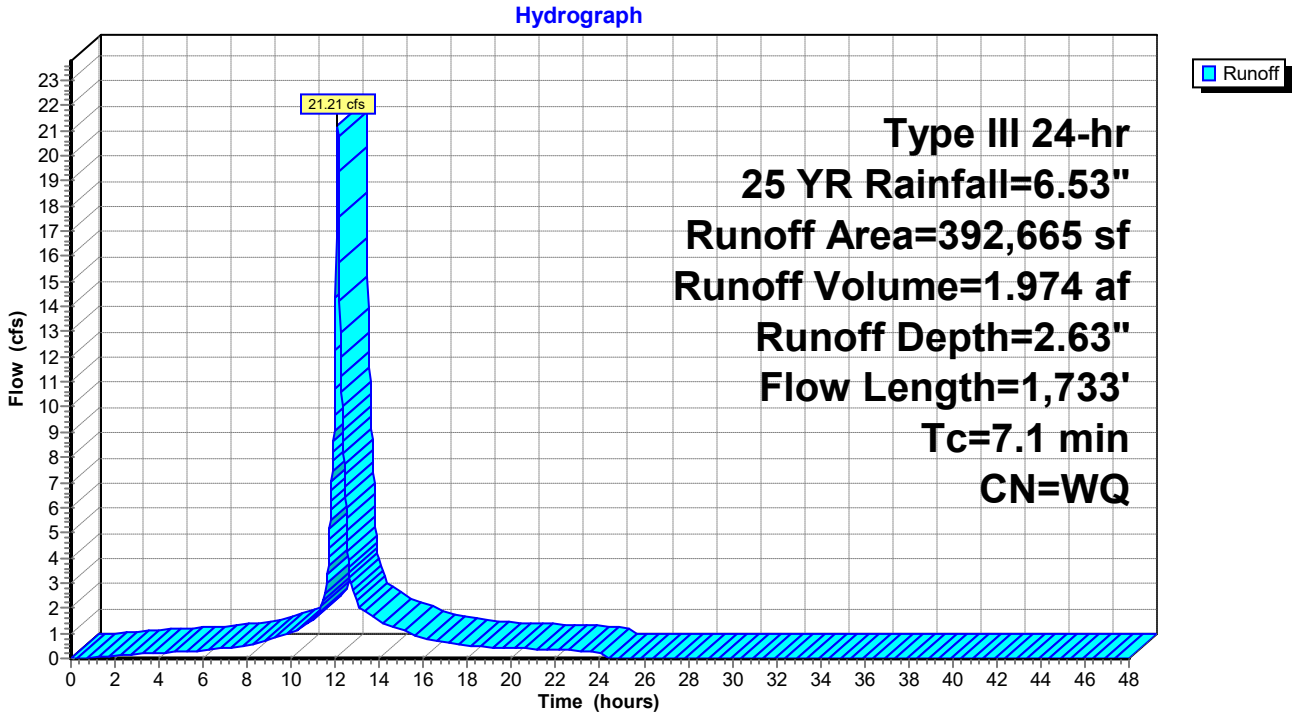
Runoff = 21.21 cfs @ 12.10 hrs, Volume= 1.974 af, Depth= 2.63"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 25 YR Rainfall=6.53"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



Summary for Pond 1P: Constructed Wetland

[81] Warning: Exceeded Pond 3P by 0.02' @ 24.40 hrs

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 2.29" for 25 YR event
Inflow = 26.28 cfs @ 12.10 hrs, Volume= 2.485 af
Outflow = 18.19 cfs @ 12.20 hrs, Volume= 2.211 af, Atten= 31%, Lag= 5.7 min
Primary = 13.23 cfs @ 12.20 hrs, Volume= 2.142 af
Routed to Pond 4P : Existing Wetland
Secondary = 4.96 cfs @ 12.20 hrs, Volume= 0.070 af
Routed to Pond 4P : Existing Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 8.73' @ 12.20 hrs Surf.Area= 10,028 sf Storage= 23,450 cf

Plug-Flow detention time= 115.4 min calculated for 2.211 af (89% of inflow)
Center-of-Mass det. time= 58.9 min (830.7 - 771.8)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	37,731 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

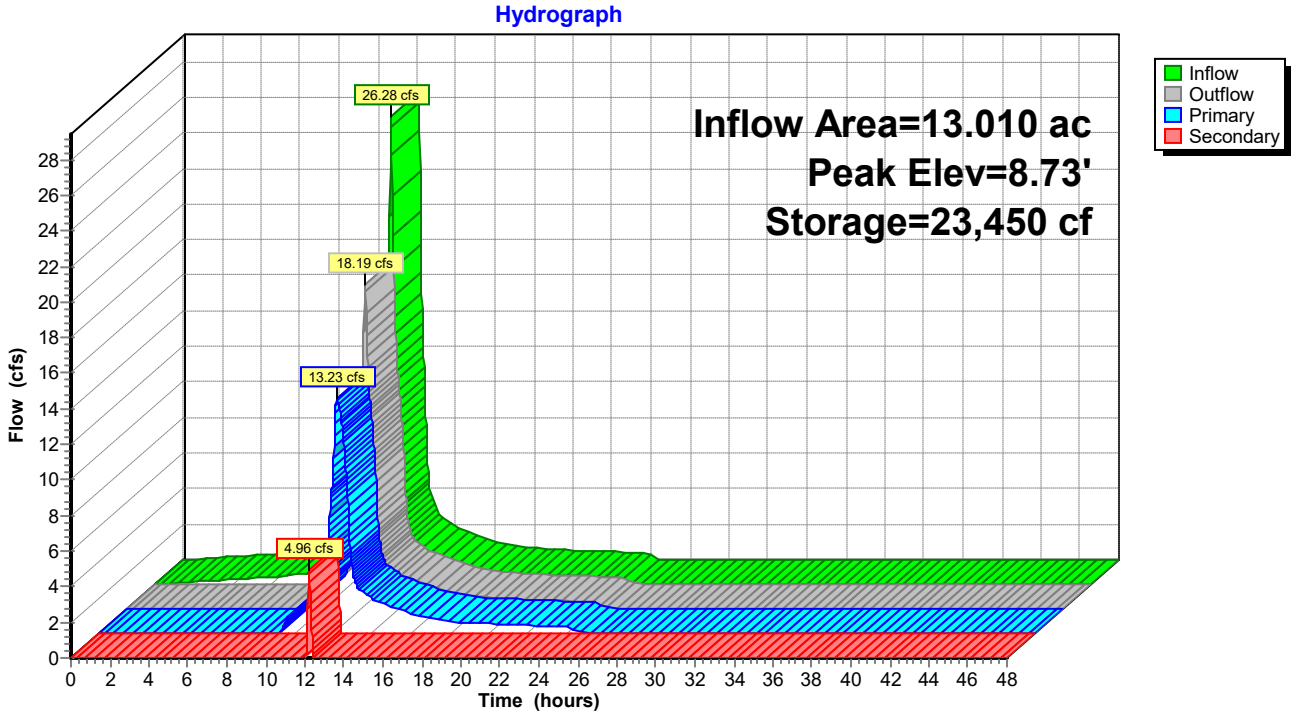
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	304	0	0
4.00	822	563	563
5.00	1,571	1,197	1,760
6.00	2,690	2,131	3,890
7.00	6,121	4,406	8,296
7.50	8,401	3,631	11,926
8.00	9,400	4,450	16,376
9.00	10,263	9,832	26,208
10.00	12,784	11,524	37,731

Device	Routing	Invert	Outlet Devices
#1	Device 2	4.50'	**24.0" Round Culvert** L= 43.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 4.00' / 4.50' S= -0.0116 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Primary	7.50'	**36.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Secondary	8.50'	**18.0' long + 4.0 '/' SideZ x 6.8' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.39 2.52 2.70 2.68 2.68 2.67 2.66 2.65 2.65 2.65 2.66 2.65 2.67 2.68 2.70 2.74 2.79

Primary OutFlow Max=13.23 cfs @ 12.20 hrs HW=8.73' (Free Discharge)
└**2=Orifice/Grate** (Passes 13.23 cfs of 37.71 cfs potential flow)
└**1=Culvert** (Inlet Controls 13.23 cfs @ 4.21 fps)

Secondary OutFlow Max=4.89 cfs @ 12.20 hrs HW=8.73' (Free Discharge)
└**3=Broad-Crested Rectangular Weir** (Weir Controls 4.89 cfs @ 1.14 fps)

Pond 1P: Constructed Wetland



Summary for Pond 3P: CDS Unit

[57] Hint: Peaked at 12.71' (Flood elevation advised)

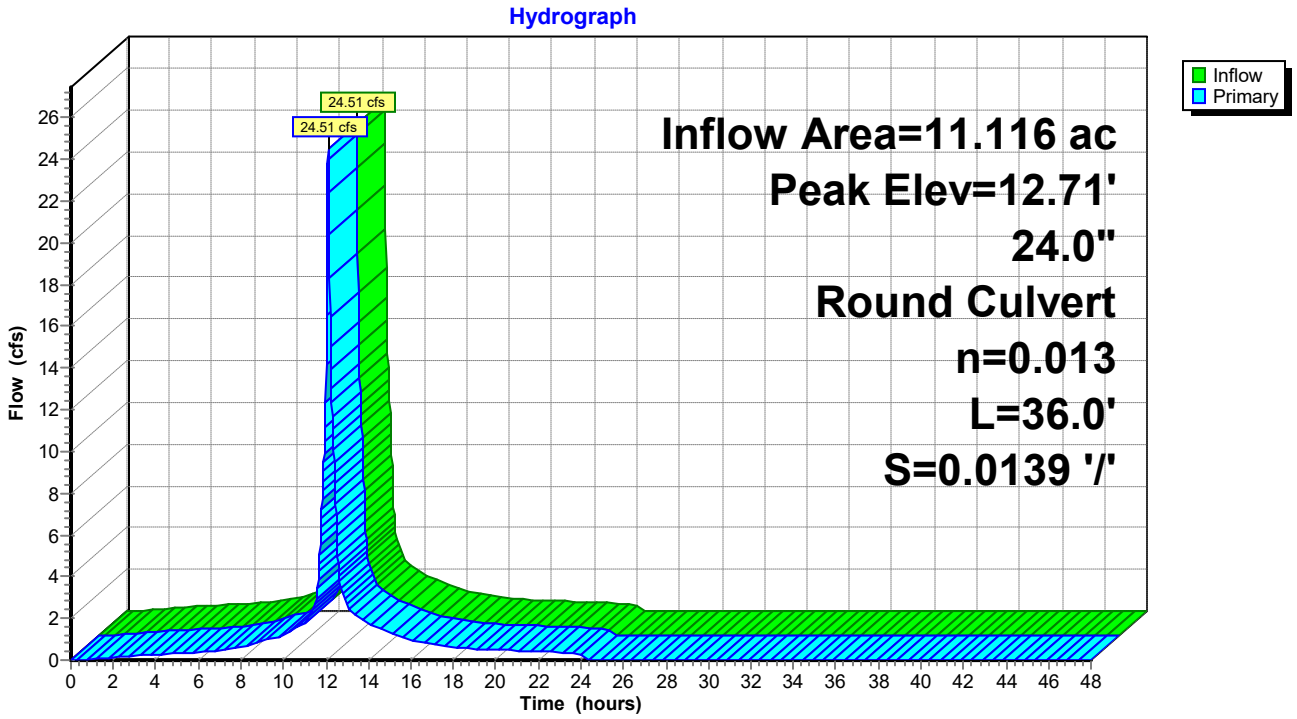
Inflow Area = 11.116 ac, 34.83% Impervious, Inflow Depth = 2.48" for 25 YR event
Inflow = 24.51 cfs @ 12.10 hrs, Volume= 2.300 af
Outflow = 24.51 cfs @ 12.10 hrs, Volume= 2.300 af, Atten= 0%, Lag= 0.0 min
Primary = 24.51 cfs @ 12.10 hrs, Volume= 2.300 af
Routed to Pond 1P : Constructed Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 12.71' @ 12.10 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	7.50'	**24.0" Round Culvert** L= 36.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 7.50' / 7.00' S= 0.0139 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=24.46 cfs @ 12.10 hrs HW=12.70' TW=7.50' (Fixed TW Elev= 7.50')
1=Culvert (Inlet Controls 24.46 cfs @ 7.79 fps)

Pond 3P: CDS Unit



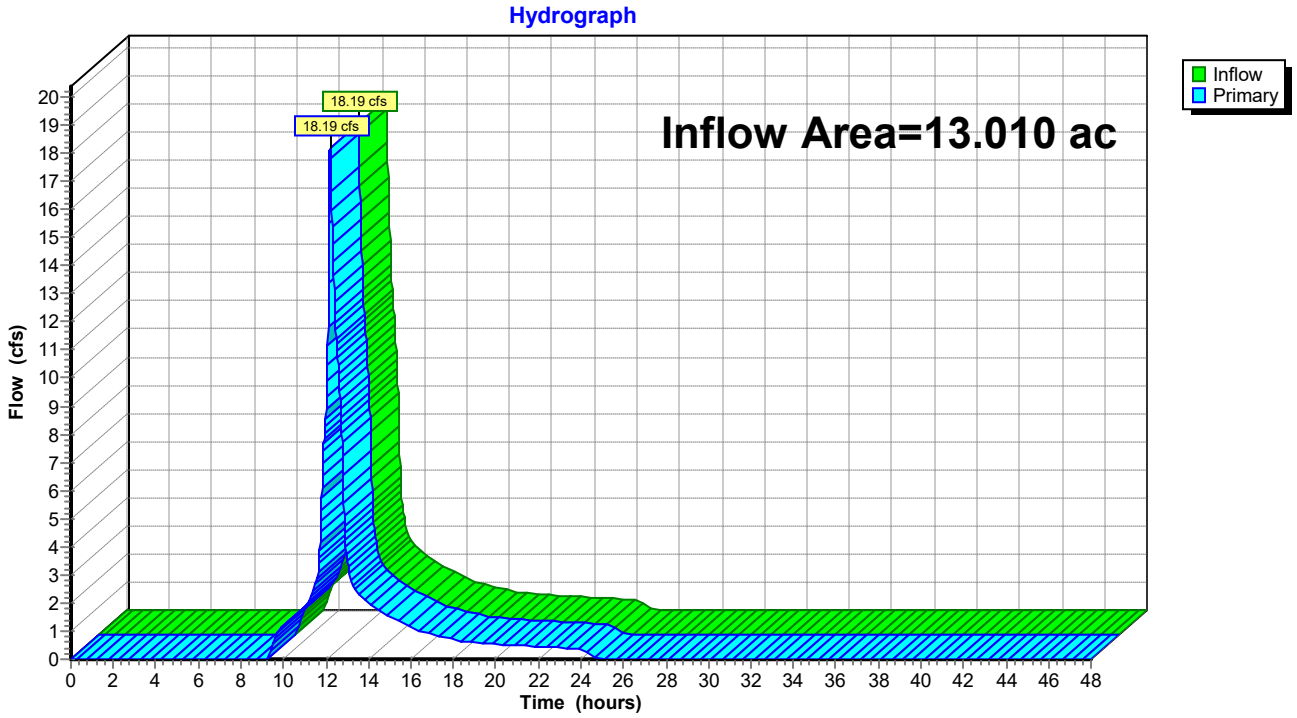
Summary for Pond 4P: Existing Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 2.04" for 25 YR event
Inflow = 18.19 cfs @ 12.20 hrs, Volume= 2.211 af
Primary = 18.19 cfs @ 12.20 hrs, Volume= 2.211 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 4P: Existing Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=1.95"
Tc=7.1 min CN=WQ Runoff=2.85 cfs 0.307 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=2.87"
Tc=7.1 min UI Adjusted CN=WQ Runoff=5.24 cfs 0.502 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=3.82"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=31.32 cfs 2.871 af

Pond 1P: Constructed Wetland Peak Elev=9.02' Storage=26,369 cf Inflow=39.41 cfs 3.681 af
Primary=14.70 cfs 3.046 af Secondary=19.10 cfs 0.361 af Outflow=33.80 cfs 3.407 af

Pond 3P: CDS Unit Peak Elev=17.87' Inflow=36.56 cfs 3.373 af
24.0" Round Culvert n=0.013 L=36.0' S=0.0139 '/' Outflow=36.56 cfs 3.373 af

Pond 4P: Existing Wetland Inflow=33.80 cfs 3.407 af
Primary=33.80 cfs 3.407 af

Total Runoff Area = 13.010 ac Runoff Volume = 3.681 af Average Runoff Depth = 3.39"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

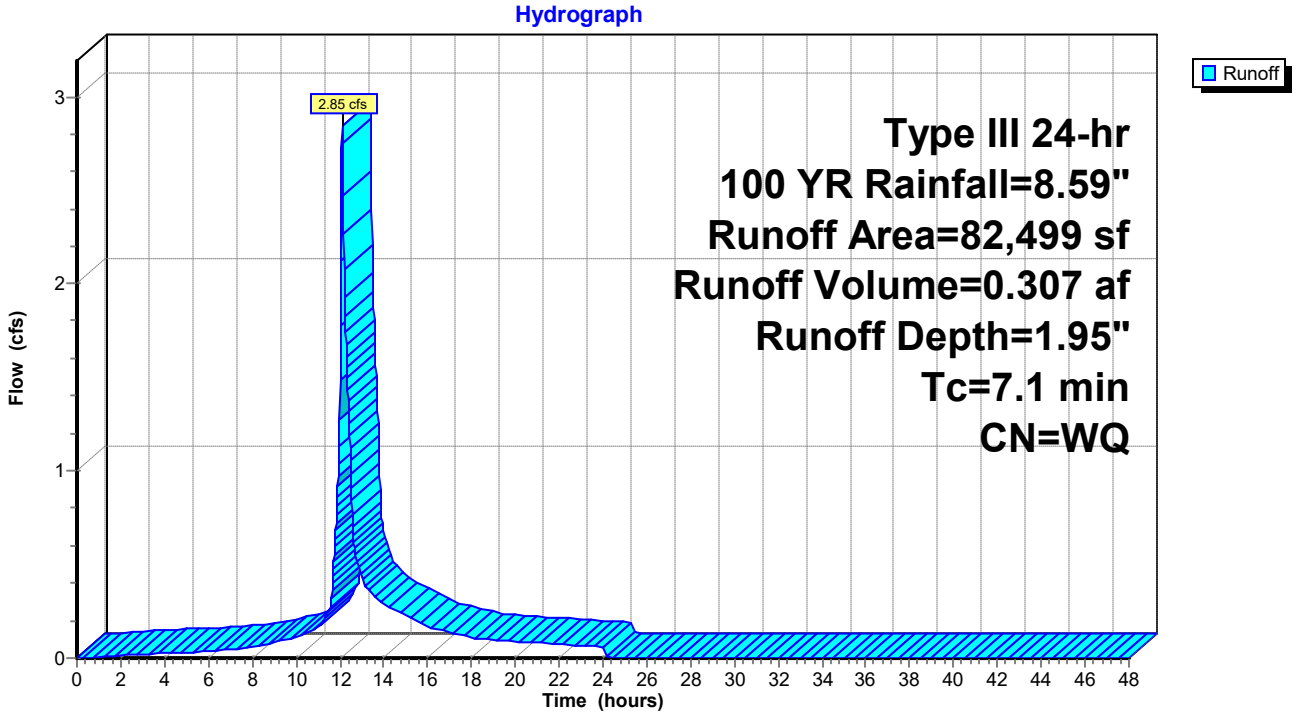
Runoff = 2.85 cfs @ 12.11 hrs, Volume= 0.307 af, Depth= 1.95"
Routed to Pond 1P : Constructed Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 YR Rainfall=8.59"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

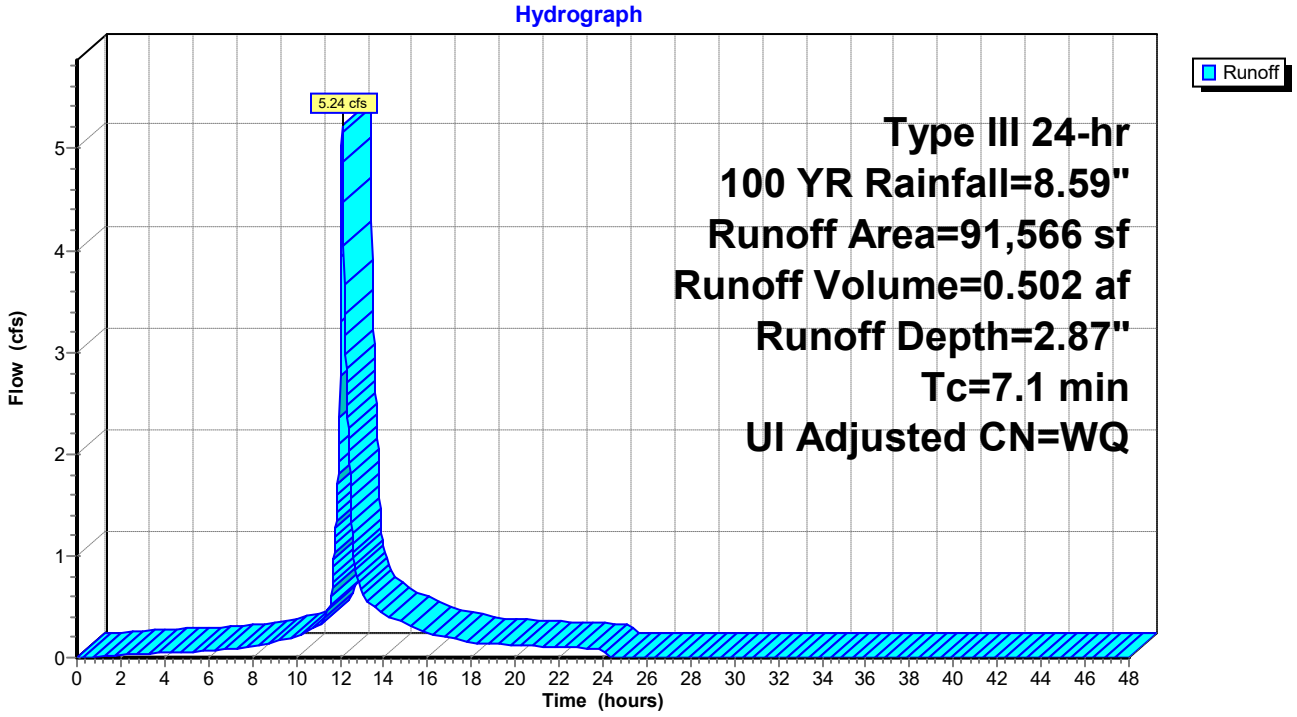
Runoff = 5.24 cfs @ 12.11 hrs, Volume= 0.502 af, Depth= 2.87"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 YR Rainfall=8.59"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

[47] Hint: Peak is 508% of capacity of segment #3

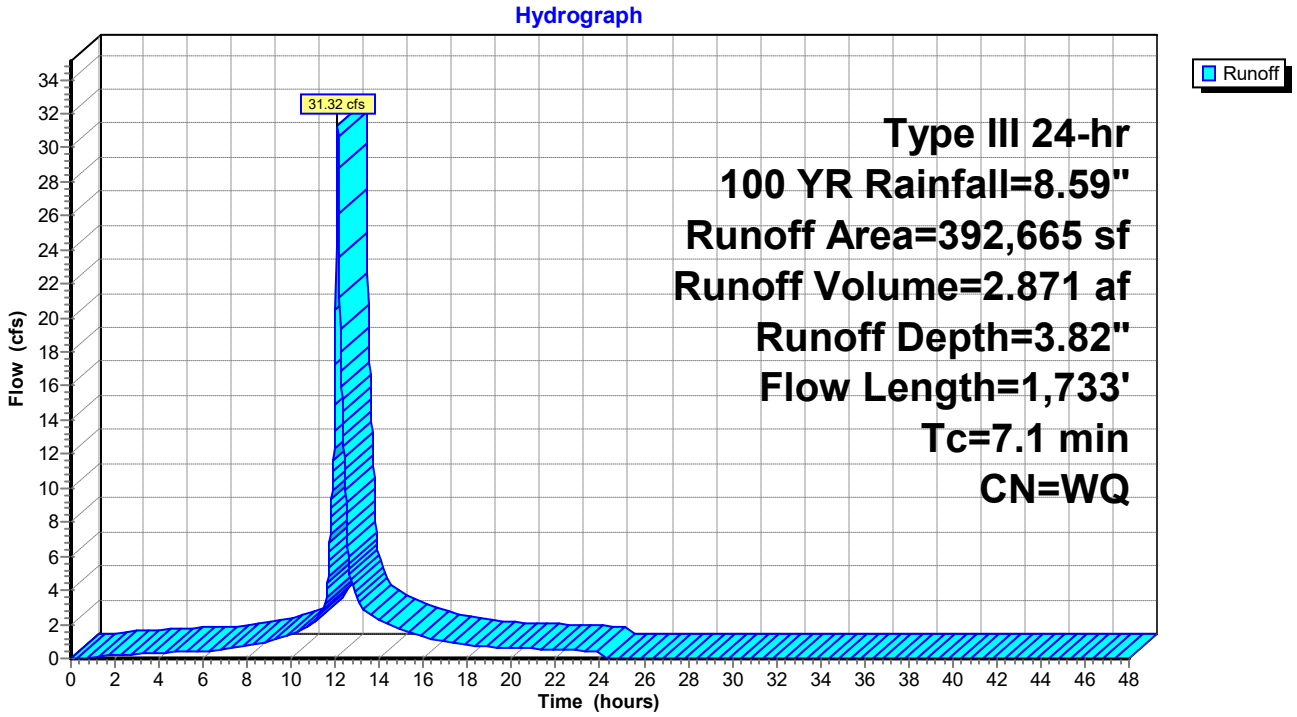
Runoff = 31.32 cfs @ 12.10 hrs, Volume= 2.871 af, Depth= 3.82"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr 100 YR Rainfall=8.59"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



Summary for Pond 1P: Constructed Wetland

[81] Warning: Exceeded Pond 3P by 0.03' @ 24.38 hrs

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 3.39" for 100 YR event
Inflow = 39.41 cfs @ 12.10 hrs, Volume= 3.681 af
Outflow = 33.80 cfs @ 12.16 hrs, Volume= 3.407 af, Atten= 14%, Lag= 3.3 min
Primary = 14.70 cfs @ 12.16 hrs, Volume= 3.046 af
Routed to Pond 4P : Existing Wetland
Secondary = 19.10 cfs @ 12.16 hrs, Volume= 0.361 af
Routed to Pond 4P : Existing Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 9.02' @ 12.16 hrs Surf.Area= 10,303 sf Storage= 26,369 cf

Plug-Flow detention time= 88.3 min calculated for 3.406 af (93% of inflow)
Center-of-Mass det. time= 46.9 min (826.5 - 779.6)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	37,731 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

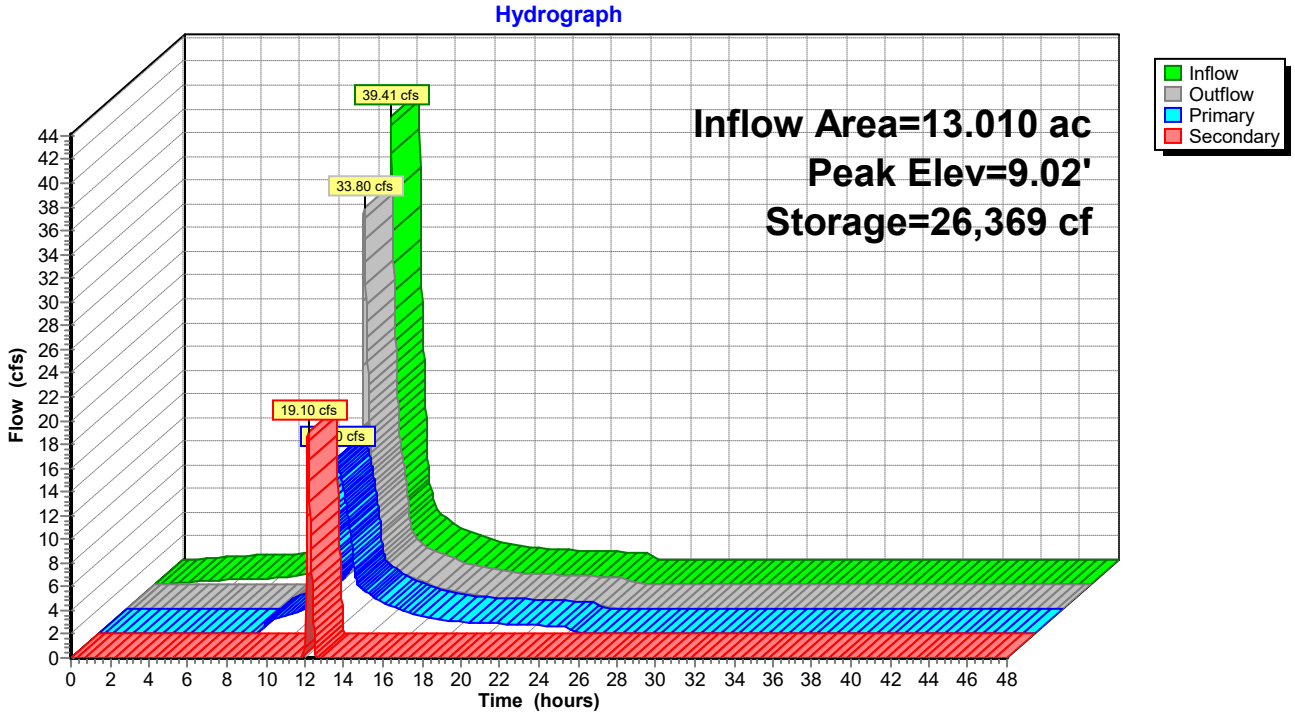
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	304	0	0
4.00	822	563	563
5.00	1,571	1,197	1,760
6.00	2,690	2,131	3,890
7.00	6,121	4,406	8,296
7.50	8,401	3,631	11,926
8.00	9,400	4,450	16,376
9.00	10,263	9,832	26,208
10.00	12,784	11,524	37,731

Device	Routing	Invert	Outlet Devices
#1	Device 2	4.50'	**24.0" Round Culvert** L= 43.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 4.00' / 4.50' S= -0.0116 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Primary	7.50'	**36.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Secondary	8.50'	**18.0' long + 4.0 '/' SideZ x 6.8' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.39 2.52 2.70 2.68 2.68 2.67 2.66 2.65 2.65 2.65 2.66 2.65 2.67 2.68 2.70 2.74 2.79

Primary OutFlow Max=14.70 cfs @ 12.16 hrs HW=9.01' (Free Discharge)
└**2=Orifice/Grate** (Passes 14.70 cfs of 41.89 cfs potential flow)
└**1=Culvert** (Inlet Controls 14.70 cfs @ 4.68 fps)

Secondary OutFlow Max=19.03 cfs @ 12.16 hrs HW=9.01' (Free Discharge)
└**3=Broad-Crested Rectangular Weir** (Weir Controls 19.03 cfs @ 1.84 fps)

Pond 1P: Constructed Wetland



Summary for Pond 3P: CDS Unit

[57] Hint: Peaked at 17.87' (Flood elevation advised)

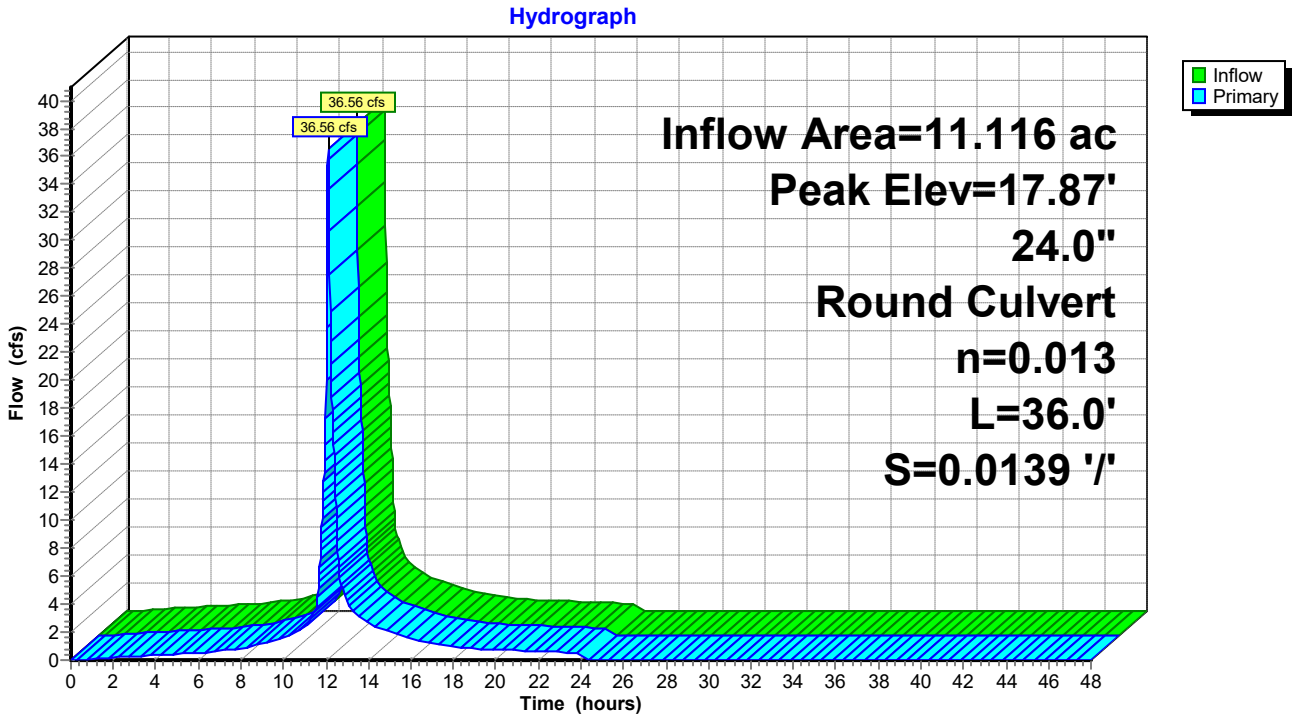
Inflow Area = 11.116 ac, 34.83% Impervious, Inflow Depth = 3.64" for 100 YR event
Inflow = 36.56 cfs @ 12.10 hrs, Volume= 3.373 af
Outflow = 36.56 cfs @ 12.10 hrs, Volume= 3.373 af, Atten= 0%, Lag= 0.0 min
Primary = 36.56 cfs @ 12.10 hrs, Volume= 3.373 af
Routed to Pond 1P : Constructed Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 17.87' @ 12.10 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	7.50'	**24.0" Round Culvert** L= 36.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 7.50' / 7.00' S= 0.0139 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=36.44 cfs @ 12.10 hrs HW=17.81' TW=7.50' (Fixed TW Elev= 7.50')
1=Culvert (Inlet Controls 36.44 cfs @ 11.60 fps)

Pond 3P: CDS Unit



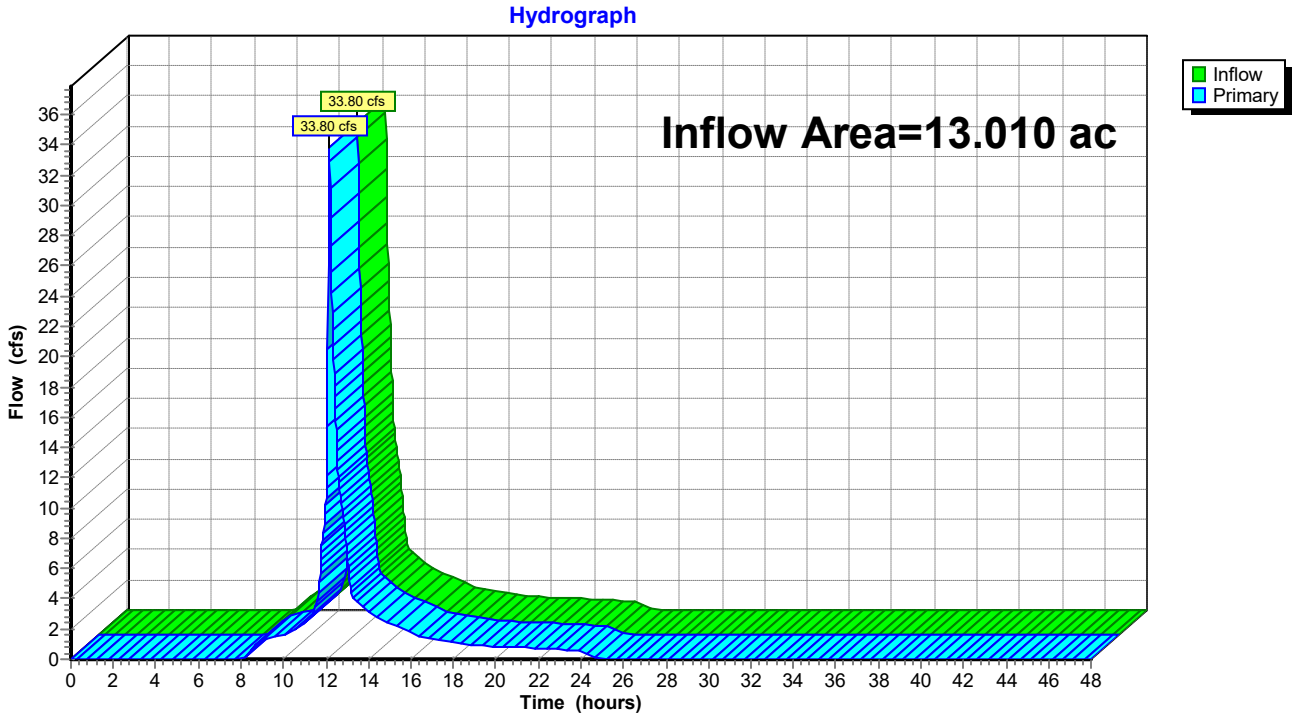
Summary for Pond 4P: Existing Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 3.14" for 100 YR event
Inflow = 33.80 cfs @ 12.16 hrs, Volume= 3.407 af
Primary = 33.80 cfs @ 12.16 hrs, Volume= 3.407 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 4P: Existing Wetland



Time span=0.00-48.00 hrs, dt=0.02 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: 0.28/1.89 Runoff Area=82,499 sf 14.53% Impervious Runoff Depth=0.14"
Tc=7.1 min CN=WQ Runoff=0.29 cfs 0.023 af

Subcatchment DA2A: 0.51/2.10 Runoff Area=91,566 sf 24.41% Impervious Runoff Depth=0.24"
Tc=7.1 min UI Adjusted CN=WQ Runoff=0.55 cfs 0.043 af

Subcatchment DA2B: 3.36/9.01 Runoff Area=392,665 sf 37.26% Impervious Runoff Depth=0.37"
Flow Length=1,733' Tc=7.1 min CN=WQ Runoff=3.57 cfs 0.279 af

Pond 1P: Constructed Wetland Peak Elev=7.52' Storage=12,137 cf Inflow=4.41 cfs 0.344 af
Primary=0.17 cfs 0.070 af Secondary=0.00 cfs 0.000 af Outflow=0.17 cfs 0.070 af

Pond 3P: CDS Unit Peak Elev=8.49' Inflow=4.12 cfs 0.321 af
24.0" Round Culvert n=0.013 L=36.0' S=0.0139 '/' Outflow=4.12 cfs 0.321 af

Pond 4P: Existing Wetland Inflow=0.17 cfs 0.070 af
Primary=0.17 cfs 0.070 af

Total Runoff Area = 13.010 ac Runoff Volume = 0.344 af Average Runoff Depth = 0.32"
68.13% Pervious = 8.863 ac 31.87% Impervious = 4.147 ac

Summary for Subcatchment DA1: 0.28/1.89

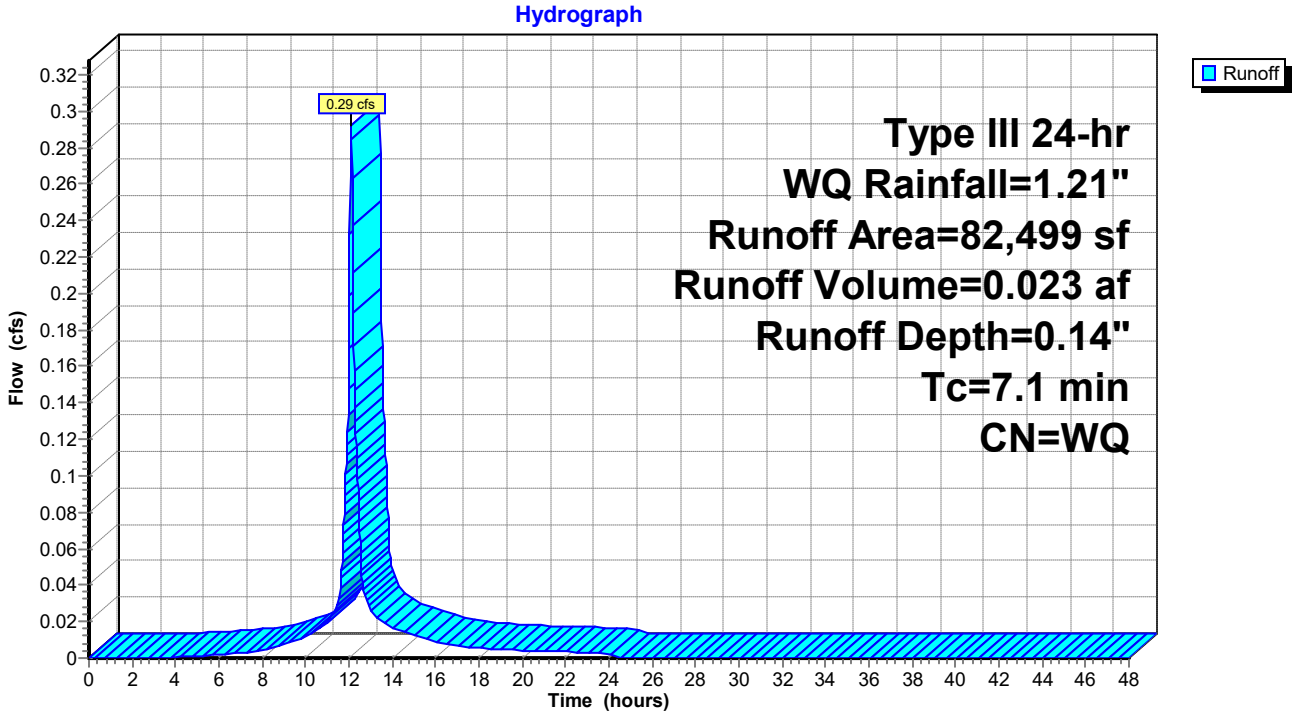
Runoff = 0.29 cfs @ 12.10 hrs, Volume= 0.023 af, Depth= 0.14"
Routed to Pond 1P : Constructed Wetland

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr WQ Rainfall=1.21"

Area (sf)	CN	Description
3,469	98	Paved parking, HSG A
8,516	98	Roofs, HSG A
46,010	30	Woods, Good, HSG A
24,504	39	>75% Grass cover, Good, HSG A
82,499		Weighted Average
70,514		85.47% Pervious Area
11,985		14.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA1: 0.28/1.89



Summary for Subcatchment DA2A: 0.51/2.10

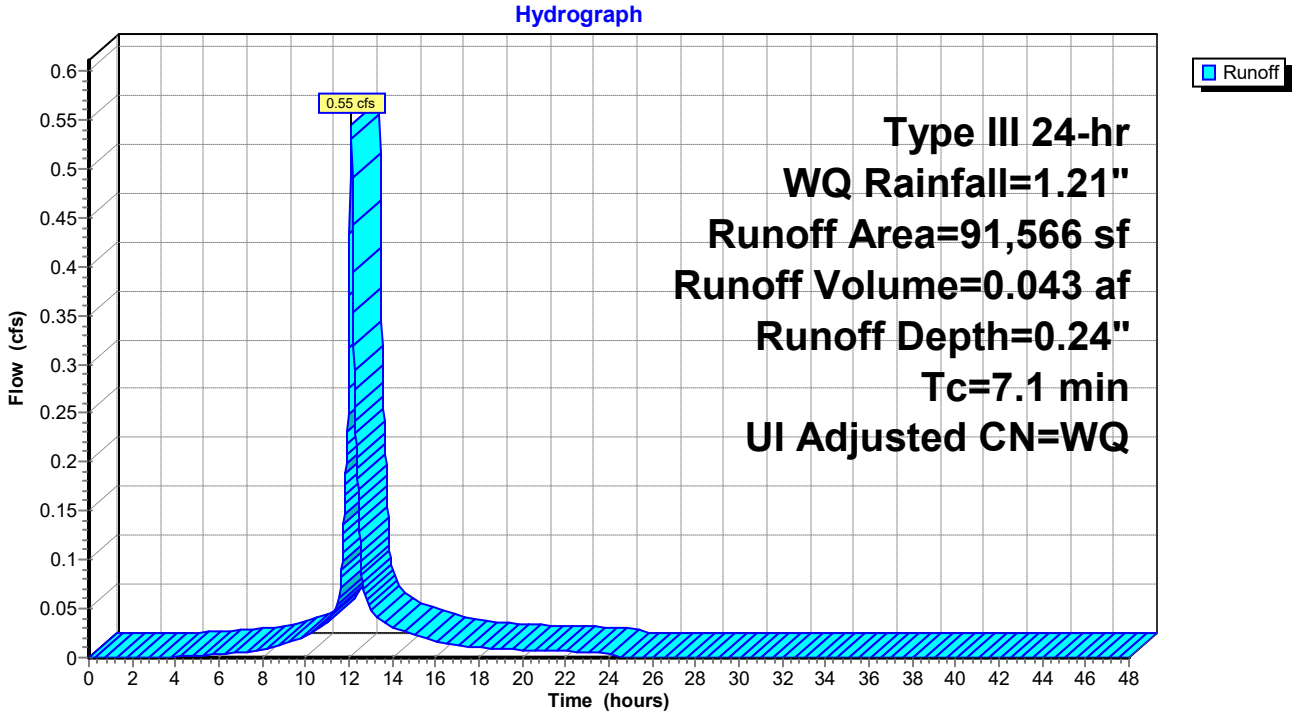
Runoff = 0.55 cfs @ 12.10 hrs, Volume= 0.043 af, Depth= 0.24"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr WQ Rainfall=1.21"

Area (sf)	CN	Adj	Description
14,426	98	98	Unconnected pavement, HSG A
7,928	98	98	Roofs, HSG A
25,978	30	30	Woods, Good, HSG A
43,234	39	39	>75% Grass cover, Good, HSG A
91,566			Weighted Average
69,212			75.59% Pervious Area
22,354			24.41% Impervious Area
14,426			64.53% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1					**Direct Entry, From DA 2B**

Subcatchment DA2A: 0.51/2.10



Summary for Subcatchment DA2B: 3.36/9.01

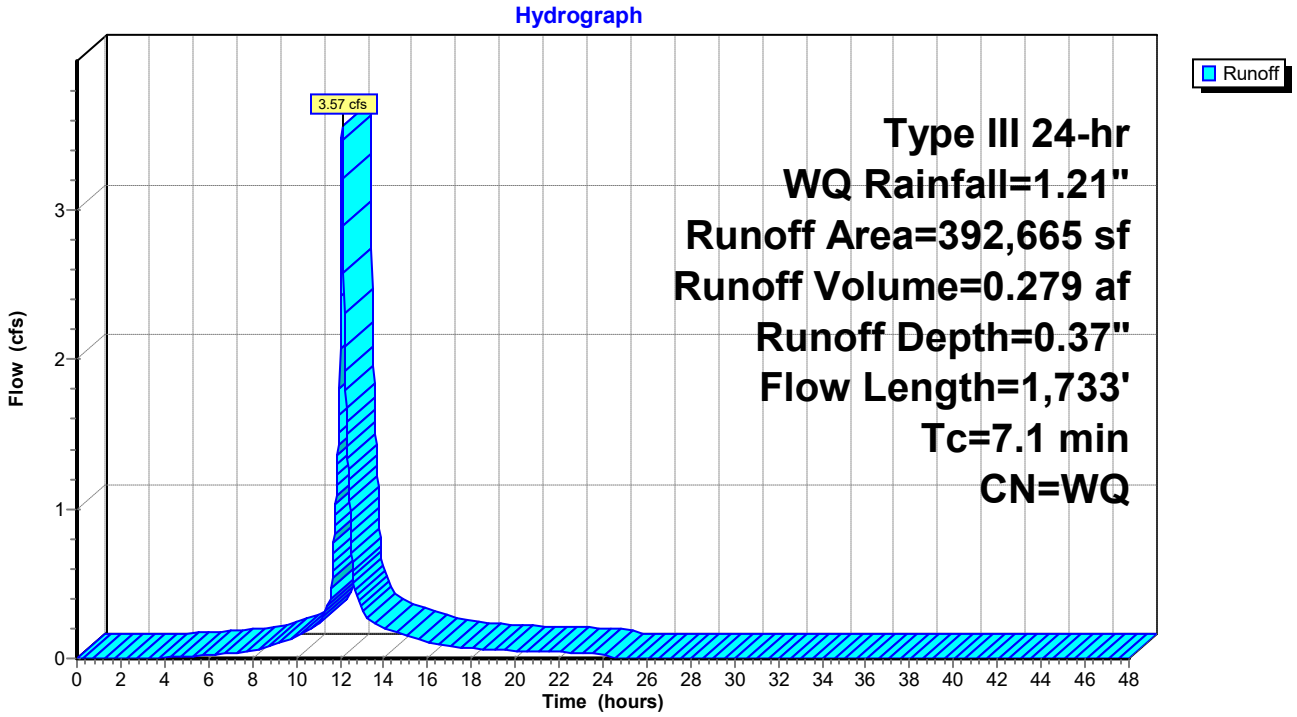
Runoff = 3.57 cfs @ 12.10 hrs, Volume= 0.279 af, Depth= 0.37"
Routed to Pond 3P : CDS Unit

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Type III 24-hr WQ Rainfall=1.21"

Area (sf)	CN	Description
110,080	98	Unconnected pavement, HSG A
35,831	98	Roofs, HSG A
394	98	Water Surface, HSG A
81,317	30	Woods, Good, HSG A
165,043	39	>75% Grass cover, Good, HSG A
392,665		Weighted Average
246,360		62.74% Pervious Area
146,305		37.26% Impervious Area
110,080		75.24% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	50	0.0100	0.96		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.60"
3.5	424	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.7	1,259	0.0300	7.86	6.17	**Pipe Channel, CMP_Round 12"** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013 Corrugated PE, smooth interior
7.1	1,733	Total			

Subcatchment DA2B: 3.36/9.01



Summary for Pond 1P: Constructed Wetland

[79] Warning: Submerged Pond 3P Primary device # 1 INLET by 0.02'

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 0.32" for WQ event
Inflow = 4.41 cfs @ 12.10 hrs, Volume= 0.344 af
Outflow = 0.17 cfs @ 15.32 hrs, Volume= 0.070 af, Atten= 96%, Lag= 193.6 min
Primary = 0.17 cfs @ 15.32 hrs, Volume= 0.070 af
Routed to Pond 4P : Existing Wetland
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Pond 4P : Existing Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 7.52' @ 15.32 hrs Surf.Area= 8,451 sf Storage= 12,137 cf

Plug-Flow detention time= 509.3 min calculated for 0.070 af (20% of inflow)
Center-of-Mass det. time= 317.5 min (1,100.3 - 782.8)

Volume	Invert	Avail.Storage	Storage Description
#1	3.00'	37,731 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

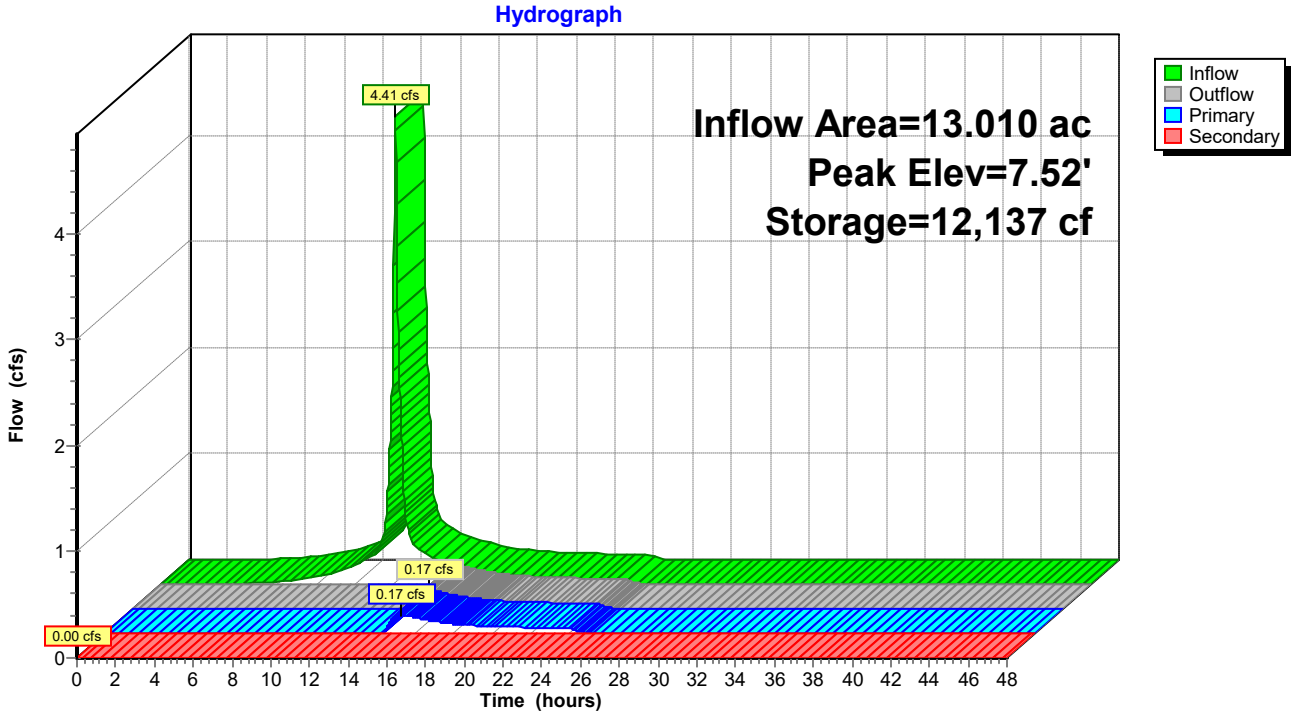
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
3.00	304	0	0
4.00	822	563	563
5.00	1,571	1,197	1,760
6.00	2,690	2,131	3,890
7.00	6,121	4,406	8,296
7.50	8,401	3,631	11,926
8.00	9,400	4,450	16,376
9.00	10,263	9,832	26,208
10.00	12,784	11,524	37,731

Device	Routing	Invert	Outlet Devices
#1	Device 2	4.50'	**24.0" Round Culvert** L= 43.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 4.00' / 4.50' S= -0.0116 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#2	Primary	7.50'	**36.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Secondary	8.50'	**18.0' long + 4.0 '/' SideZ x 6.8' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.39 2.52 2.70 2.68 2.68 2.67 2.66 2.65 2.65 2.65 2.66 2.65 2.67 2.68 2.70 2.74 2.79

Primary OutFlow Max=0.12 cfs @ 15.32 hrs HW=7.52' (Free Discharge)
└**2=Orifice/Grate** (Weir Controls 0.12 cfs @ 0.52 fps)
└**1=Culvert** (Passes 0.12 cfs of 1.89 cfs potential flow)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=3.00' (Free Discharge)
└**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 1P: Constructed Wetland



Summary for Pond 3P: CDS Unit

[57] Hint: Peaked at 8.49' (Flood elevation advised)

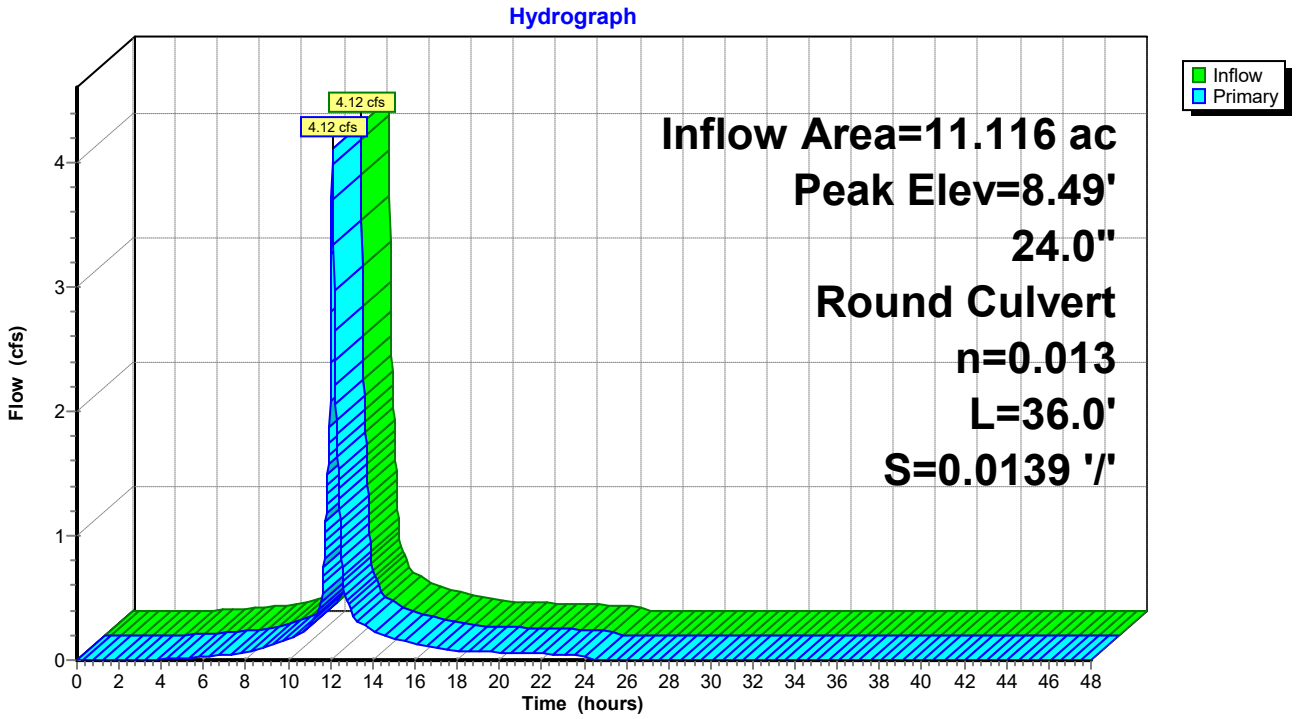
Inflow Area = 11.116 ac, 34.83% Impervious, Inflow Depth = 0.35" for WQ event
Inflow = 4.12 cfs @ 12.10 hrs, Volume= 0.321 af
Outflow = 4.12 cfs @ 12.10 hrs, Volume= 0.321 af, Atten= 0%, Lag= 0.0 min
Primary = 4.12 cfs @ 12.10 hrs, Volume= 0.321 af
Routed to Pond 1P : Constructed Wetland

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs
Peak Elev= 8.49' @ 12.10 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	7.50'	**24.0" Round Culvert** L= 36.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 7.50' / 7.00' S= 0.0139 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=4.11 cfs @ 12.10 hrs HW=8.48' TW=7.50' (Fixed TW Elev= 7.50')
1=Culvert (Inlet Controls 4.11 cfs @ 2.67 fps)

Pond 3P: CDS Unit



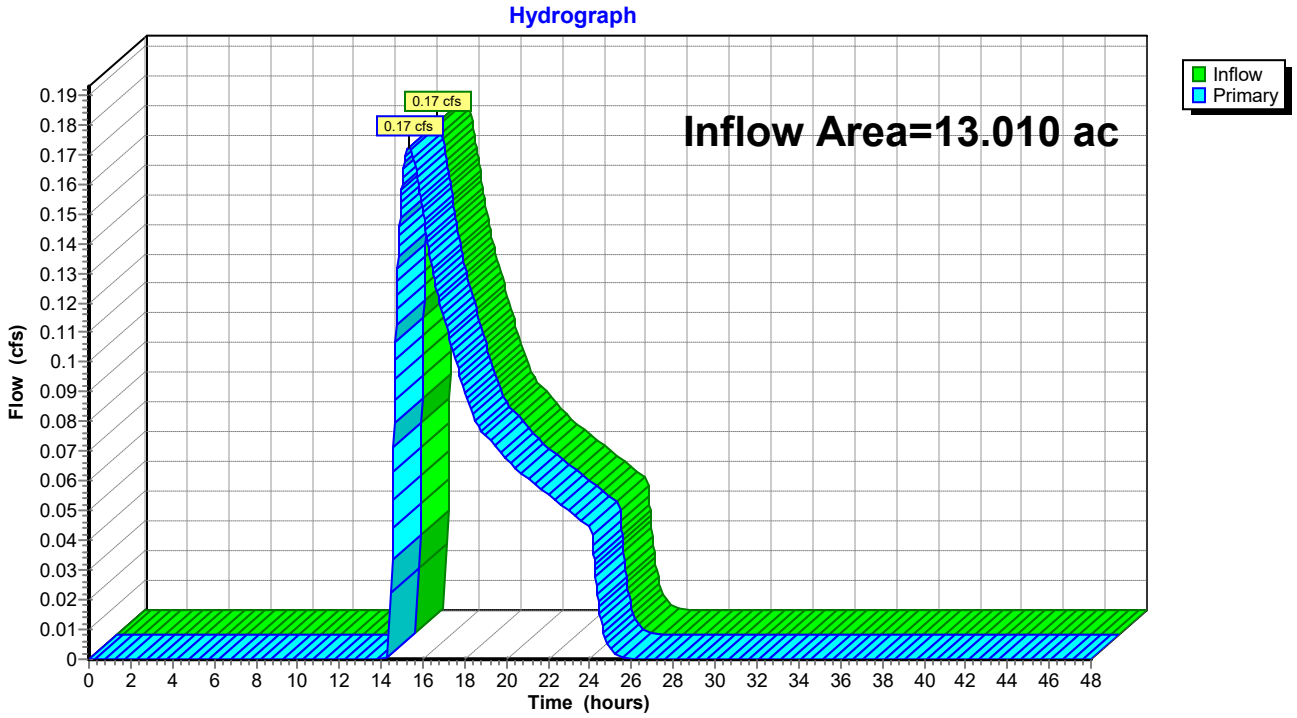
Summary for Pond 4P: Existing Wetland

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

Inflow Area = 13.010 ac, 31.87% Impervious, Inflow Depth = 0.06" for WQ event
Inflow = 0.17 cfs @ 15.32 hrs, Volume= 0.070 af
Primary = 0.17 cfs @ 15.32 hrs, Volume= 0.070 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.02 hrs

Pond 4P: Existing Wetland



Estimated Net Annual Solids Load Reduction
Based on the Rational Rainfall Method

CONTECH ENGINEERED SOLUTIONS

CASCADE separator™

CURVE HILL
YARMOUTH, MA
HDS

AREA	11.11	acres	**CASCADE MODEL**	CS-6	
WEIGHTED C	0.51		**PARTICLE SIZE**	110	microns
TC	5.00	minutes	**RAINFALL STATION**	66	

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Hydraulic Loading Rate (gpm/ft2)	Removal Efficiency (%)	Incremental Removal (%)
0.08	35.3%	7.20	100.0	35.3
0.16	23.8%	14.39	98.4	23.4
0.24	12.9%	21.59	91.6	11.8
0.32	7.8%	28.78	84.8	6.6
0.40	4.9%	35.98	78.1	3.8
0.48	3.5%	43.17	71.3	2.5
0.56	1.7%	50.37	64.6	1.1
0.64	1.8%	57.56	57.8	1.1
0.72	1.9%	64.76	51.0	1.0
0.80	0.9%	71.96	44.3	0.4
1.00	2.3%	89.94	27.4	0.6
2.00	2.9%	115.09	2.4	0.1
3.00	0.2%	115.09	1.6	0.0
				87.7
			Removal Efficiency Adjustment[2] =	0.0%
			Predicted % Annual Rainfall Treated =	98.8%
			Predicted Net Annual Load Removal Efficiency =	**87.7%**

1 - Based on 14 years of 15 minute precipitation data from NCDC station 3821, Hyannis, in Barnstable County, MA

2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

APPENDIX C – Soil Test Pit Logs

Commonwealth of Massachusetts

City/Town of Yarmouth

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review

Deep Observation Hole Number: 1 (Hole #) | 1/4/24 (Date) | 1200P (Time) | 40F Sun (Weather) | 41º41'08.88"N (Latitude) | 70º10'07034"W (Longitude)

1. Land Use: Conservation land (e.g. woodland, agricultural field, vacant lot, etc.) | Scrub oak and pine (Vegetation) | No (Surface Stones (e.g. cobbles, stones, boulders, etc.)) | 3-8 (Slope (%))

Description of Location: South side of Curve Hill Rd in front of #7 | 11.2 (Surface elevation)

2. Soil Parent Material: Sandy glaciofluvial deposits | Moraines, outwash plains (Landform) | (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances From:

Open Water Body	>200 feet	Drainage Way	feet	Wetlands	>200 feet		
Property Line	10 feet	Drinking Water Well	feet	Other	feet		

4. Unsuitable Materials Present: ☐ Yes ☑ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☑ Yes ☐ No If Yes: 63" Depth weeping from pit ____ Depth standing water in hole

Soil Log

Depth (in)	Soil Horizon/ Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles/Stones			
0-4	A	MS	10YR 3/2				-	-	M	Fr	
4-18	E	MS	10YR 2/1				-	-	M	Fr	
18-42	B	MS	10YR 3/6				-	-	M	Fi	
42-75	C	CS	10YR 8/1				-	-	M	Fi	

Additional Notes:

APPENDIX D – Operation and Maintenance Guide

Stormwater Operations & Maintenance Guide

Curve Hill Road Stormwater Retrofit Project

Table of Contents

APPENDICES

1. INTRODUCTION

This document provides a general description along with the operation and maintenance requirements for the Curve Hill Road Stormwater Retrofit project, located at Curve Hill Road in Yarmouth, Massachusetts. The responsible parties are required to inspect and maintain all measures as outlined in this maintenance guide throughout the year. Site maintenance is divided into three categories as outlined below.

1. Green Stormwater Infrastructure
    - Structural Components
    - Structural Maintenance Schedule
    - Planting
    - Landscape Maintenance Schedule
    - Weed Guide
2. General Site Maintenance
    - Trash & Debris
    - Pet Waste
    - Pavement Sweeping
    - Contributing Drainage Areas
    - Snow Removal
    - De-icing
3. Long-Term Pollution Prevention Measures

2. RESPONSIBLE PARTIES AND BUDGET

The Curve Hill Road site is Town-owned property. The drainage from Great Western Road and Curve Hill Road is Town-owned roads. The Town will provide staff, volunteers as possible, and funding for the long-term O&M at the site. The estimated average annual O&M budget for the proposed system is shown below:

- **Constructed Wetland:** **$1,000**
  ($1,000/Wetland)
- **Drainage Structures (WQU 100)** **$500**
  ($500/structure)

Owner contact information is provided below:

Owner: **Town of Yarmouth**
Contact: **Department of Public Works**
Amanda Lima, Town Engineer
74 Town Brook Road
West Yarmouth, MA 02673
508-398-2231

Contact: **Division of Natural Resources**
Bill Bonnetti
424 Route 28
West Yarmouth, MA 02673
508-760-4800

Owner - Signature:_____ Date:_____

Owner - Signature:_____ Date:_____

3. GREEN STORMWATER INFRASTRUCTURE

3.1. How Does Green Infrastructure Work?

Green Stormwater Infrastructure (GSI) is a nature-based approach to stormwater treatment and management. These stormwater practices or "treatment areas" are designed to mimic nature and use the natural filtration properties of soil and plants to remove pollutants from stormwater runoff prior to discharging to the municipal drainage system or waterbodies.

GSI relies on the following basic steps to function properly. Structural components of the practices facilitate the functioning of the steps. If one of these steps, or components, does not work properly, the entire system can be compromised and the GSI practice itself could be contributing to maintenance problems. This can lead to landscape nuisances, more frequent maintenance, and costly repairs/improvement. The steps are:

1. ***Collect*** (Inlets)
2. ***Move Water*** (Conveyance) if needed, can come after capturing sediment
3. ***Capture Sediment*** (Pretreatment)
4. ***Treat and Manage*** (Filter, Infiltrate or Store)
5. ***Overflow*** (Structures and Spillways)

3.2. What is required for Maintenance?

As these are nature-based systems that rely on plant upkeep, the maintenance for GSI typically falls under landscape and general site maintenance services. Proper operation and maintenance (O&M) are vital to its long-term viability. Regularly scheduled maintenance can prevent system failures due to sediment build-up, damage, or deterioration. The maintenance requirements outlined in this guide are critical to ensure proper treatment, maintain storage capacity and preserve the visual integrity.

General maintenance includes the following:

1. Removing sediment from the pretreatment practices used to capture sediment.
2. Maintaining the proper drainage function and pollutant removal capacity of the systems.
3. Maintaining healthy native trees, plants, and vegetative cover as well as the removal of unwanted weeds and invasive species.

It is recommended that all practices be maintained regularly as part of the routine landscape maintenance or at a minimum four times per year and after major rain events:

- **Early Spring**: during spring cleanup
- **Summer:** during lawn mowing and other routine site maintenance
- **Early Fall:** when leaves begin to fall
- **Late Fall/Early Winter:** after all the leaves have fallen during leaf removal
- **After major storm events**: 2" of rain or greater.

The following sections describe the general function and landscape maintenance of each practice on the site. Included in the appendices is a specific Inspection Report for the site (**Appendix A**) along with a plan showing the location of the items to be inspected and maintained (**Appendix B**).

3.3. What practices are used at this site?

The following practices are present at this site:

a. Constructed Wetland: a constructed wetland provides temporary storage in shallow and deep pools that support wetland habitat. Similar to natural wetlands, constructed wetlands use natural processes to treat the stormwater: uptake through vegetation, sedimentation, and biological processes.

b. Water Quality Unit: this structure provides the pretreatment prior to the stormwater discharging into the constructed wetland.

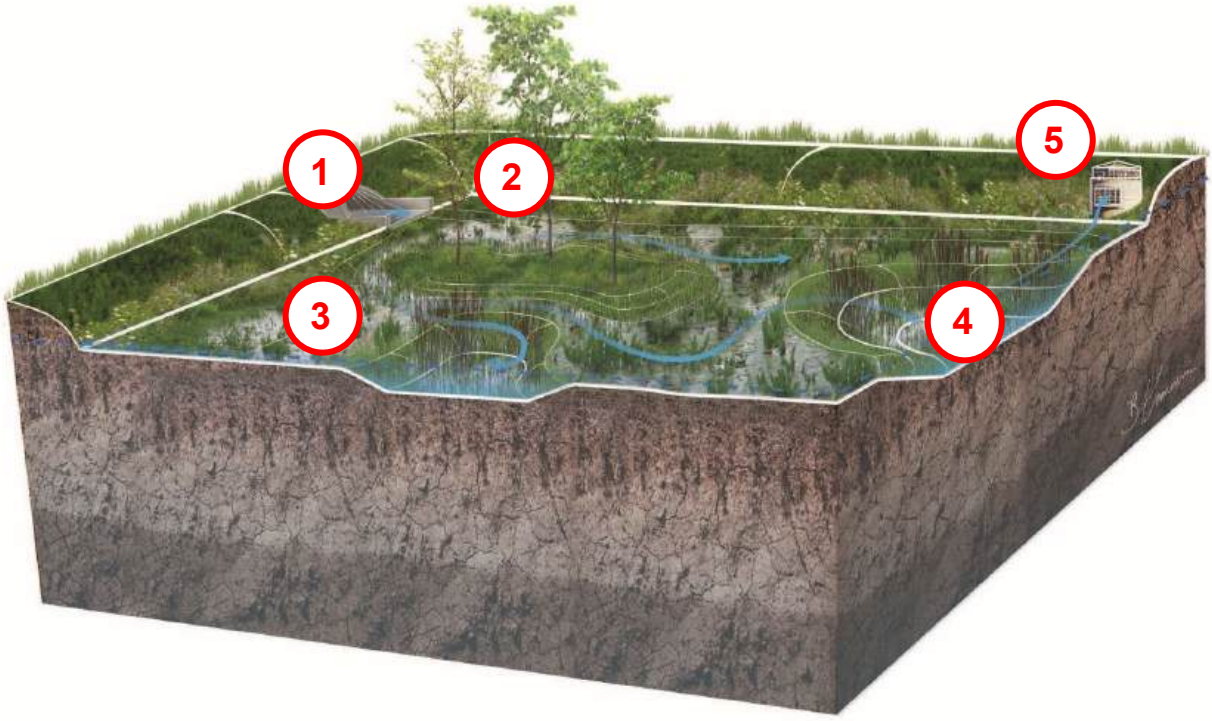
The maintenance for the green infrastructure is divided into two categories:

a. The **Structural Components** that make up the basic steps of a functioning system.

b. The **Plantings** that are the landscape and filtration element.

Each category is further described in the sections below.

4. STRUCTURAL COMPONENTS: CONSTRUCTED WETLAND



Structural Components

1. ***Collect***: Stormwater runoff is directed to through a pipe routing to the initial stabilized outfall and wetland cell where stormwater enters the system.

2. ***Capture Sediment***: Sand and debris settle out within the Water Quality Unit and the first wetland cell.

3. ***Move Water:*** Stormwater moves from low marsh areas to micropools which provide additional treatment through sedimentation as well as plant uptake.

4. ***Treat and Manage***: Plants in the constructed wetland help to slow the water down and water is treated when it filters through the soil and plant roots. Planted vegetation remove phosphorous and bacteria and allow stormwater to infiltrate into the soil.

5. ***Overflow***: A reverse slope pipe will discharge stormwater through an outlet bubbler to the existing wetland. During larger rain events, stormwater will spill over the stabilized overflow spillway.

MAINTENANCE SCHEDULE: CONSTRUCTED WETLAND

A site inspection of the constructed wetland components, including the water quality unit used for pretreatment, shall be conducted at least twice a year in the Spring and Fall, and after major storm events (2" of rain or greater). Debris and trash should be removed monthly (between April and November) and sediment removal should occur during the two site inspections and during the monthly debris and trash inspections as needed. See the calendar below and the Inspection Report in **Appendix A** for more information.

Constructed Wetland and Water Quality Unit General Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Site Inspection				**X**							**X**	
Debris & Trash Removal				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Sediment Removal				**X**	x	x	x	x	x	x	**X**	

should **also** be completed after major storm events

X required inspection

x as needed

See Plantings section for information on plantings maintenance of the constructed wetland. Use the plantings maintenance calendar to combine maintenance efforts.

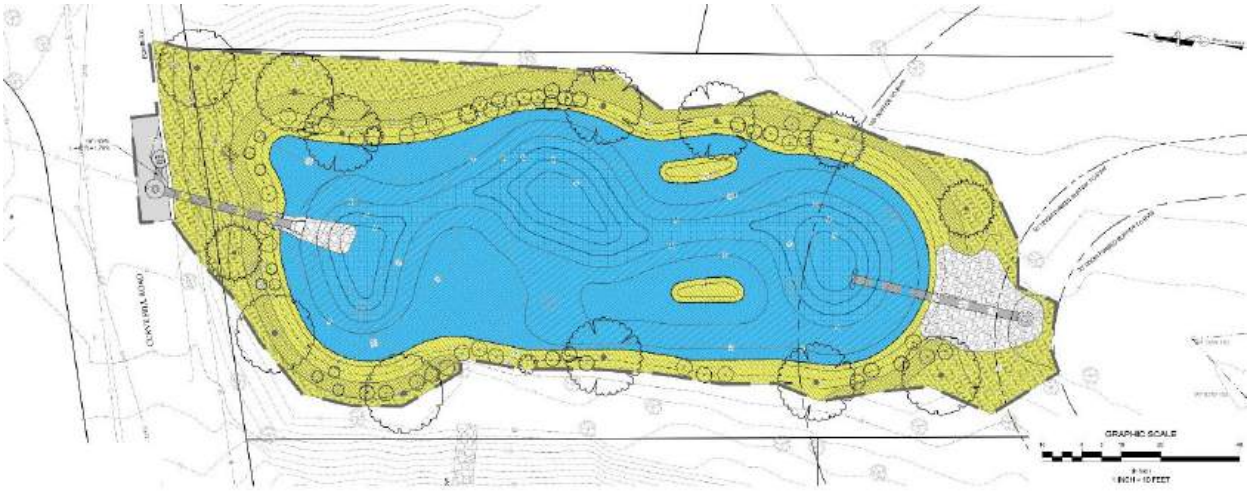
5. PLANTINGS

5.1. Plantings

By design, plants in constructed stormwater wetland practices filter stormwater to remove pollutants through uptake, retention, and settling, while providing visual interest and wildlife habitat year-round. These plantings do not require fertilizers, watering, or mowing. The planting design for the site consists of a "no mow" maintenance strategy including wetland edge plantings and wetland plantings. The plantings maintenance checklist is included in **Appendix A**, and the full planting plan is available in **Appendix D**.

Wetland Edge

Wetland



PLANTINGS: WETLAND AND WETLAND EDGE AREA MAINTENANCE

By design, plants in constructed wetlands are meant to flourish throughout the growing season leaving dry standing stalks during the dormant months. Plants do not require fertilizers or watering (except during drought or establishment period). The project area is designated as "no mow" with both Wetland Edge and Wetland Plantings. Remove and replace vegetation as necessary, using the appropriate species as shown on the Planting Plan. The best time to plant is in early to mid-fall or early to mid-spring. Specific maintenance activities include:

Seeding and Planting

Loam, reseed and plant bare spots with the specified species and seed mix as shown on the Planting Plan.

Cutting Back

It is not recommended to cut back plantings within the wetland. If cutting is necessary along the wetland edge, cut by hand with shears a maximum of once a year in mid spring. Otherwise, allow areas to grow to their natural heights to maintain a natural wetland appearance. Do NOT cut any wetland edge area lower than 6" – maintain sporadic wooden stakes on site at 6" height to provide visual cues during cutting. Depending on height of grasses and the time of year, grass cuttings/stalks may need to be raked and removed from site so as not to clog the constructed wetland. Use a leaf blower as needed to assist in clean-up.

Mowing/Weed Whacking

Do not mow or weed whack this area.

Pruning

Prune trees and shrubs to remove deadwood and low hanging branches.

Watering

Water only during drought conditions or during seeding/plant establishment period.

Fertilizing

No fertilizer shall be used.

Weeding

Weeding should be limited to invasive and weedy species (see section on Weed Identification below and the Weed Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf). Non-chemical methods (hand pulling and hoeing) are required; chemical herbicides should be avoided. Properly remove and dispose off site all invasive species as to prevent colonization elsewhere; this includes disposal on land beyond the project area.

Monitoring

During the establishment period, walk the wetland edge monthly to look for invasive and weedy species, bare spots, and to identify potential pest or disease problems. Carefully remove and dispose of all

invasive and weedy species to prevent colonization elsewhere. This includes disposal on land beyond the project area.

Observe and map the following on a bi-annual basis, for the first three years, minimum:

- The types and distribution of the dominant wetland plants in the constructed wetland
- The presence and distribution of planted wetland species
- The presence and distribution of invasive wetland species (invasives must be removed)
- Indications that other species are replacing the planted wetland species
- Percentage of standing water that is unvegetated (excluding the deep water cells which are not suitable for emergent plant growth)
- The maximum elevation and the vegetative condition in this zone,
- Stability of the original depth zones and the micro-topographic features
- Accumulation of sediment in the forebay and micropool; and survival rate of plants (cells with dead plants must be replanted)

Debris & Trash

Remove and properly dispose of litter from all areas.

PLANTINGS: REPLACEMENTS

Plants in constructed wetlands require varying levels of inundation and filter out pollutants. The plants along the wetland edge need to withstand periods of drought during dry months and water inundation during the wet season and large rain storms.

If replacements are needed, use the planting plan as a guide (see **Appendix D**). However, if a certain species of plants has not done well in the constructed wetland, do not replace with that same species. Rather, replant with one or more of the other species that has thrived under the site conditions at similar depths, or have a wetland bilogist choose a different species based on current photos of the site. Replacement plants selected should be native to the local area to provide additional habitat and pollinator value.

The following should be considered when selecting plants for a constructed wetland:

- Use native and pollinator-friendly plants.
- Adaptable to both drought conditions for short periods of time and water inundation based on the location and water depths within the wetland.
- Be salt and wind tolerant
- Use a mix of different plant species that will create a resilient plant community including cold & warm season grasses, perennials, emergent aquatic vegetation, and groundcovers in all areas.

PLANTINGS: MAINTENANCE SCHEDULE

By design, plants in the constructed wetland are meant to filter the stormwater as it temporarily stores stormwater to remove pollutants by means of uptake, retention, or settling (Massachusetts Stormwater Handbook). The plantings also flourish throughout the growing season. The plants do not require fertilizers or mulch, and, after establishment, only need water during periods of drought. Remove and replace vegetation as necessary, using the appropriate species as discussed in the section above. Weeding and monitoring for invasive species should occur quarterly during the growing season. An annual spring "clean up" includes pruning as needed. See the calendar below, the Plantings Maintenance Checklist in **Appendix A**, the Weed Identification section, and the Weed Identification Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf for more information.

https://www.mass.gov/doc/massachusetts-stormwater-handbook-vol-2-ch-2-stormwater-best-management-practices/download

Constructed Wetland Annual Landscape Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Cutting				**X**								
Weeding				**X**		**X**			**X**		**X**	
Monitoring				**X**		**X**			**X**		**X**	
Watering						x	x	x	x			
Seeding				x	x				x	x		
Plant Replacement				x	x				x	x		

X required
x as needed

Yellow Toadflax *(Linaris vulgaris)*

Redroot Pigweed- (*Amaranthus retroflexus)*

Smartweed *(Polygonum lapathifolium)*

Dandelion *(Taraxacum officinale)*

Fireweed *(Erechtites hieracifolia)*

Spotted Spurge (Euphorbia maculata)

Crabgrass *(Digitaria ischaemum)*

Crabgrass with seedheads

Ragweed (*Ambrosia artemisiifolia*)

Japanese Knotweed (Polygonum cuspidatum)

Ragweed (*Ambrosia artemisiifolia*)

Oriental Bittersweet (*Celastrus orbiculatus*)

Green Foxtail (Setaria viridis)

Norway Maple Tree Seedling (Acer platanoides)

Catalpa Tree Seedling (Catalpa speciosa)

Purple Loosestrife (*Lythrum salicaria*)

Field Bindweed (*Convolvulus arvensis*)

Black Swallow-wort (*Cynanchum louisea*)

6. GENERAL SITE MAINTENANCE

General site maintenance includes the following requirements:

Trash & Debris

Remove and properly dispose of all trash and debris.

Pet Waste

Visitors to the site are encouraged to pick up after their pets. Remove and properly dispose of all pet waste left behind. Pet waste should be picked up and disposed of properly to reduce bacteria and nutrient levels in stormwater.

Pavement Sweeping

Paved roadways should be mechanically swept, at a minimum of once per year in early spring, to remove accumulated sand and sediment debris.

Snow Removal

Due to the potential for plant damage, snow piling and or removal is NOT recommended in the constructed wetland area.

De-Icing

When de-icing compounds are necessary for areas draining to the green stormwater infrastructure, the least harmful chemicals should be used. Excessive salting should be avoided. Use of large amounts of sand should also be avoided, since it may obstruct the conveyance system.

Mosquito Management

Mosquitoes are common in natural wetlands and can be expected in constructed wetlands. Immediately after construction has completed, prior to emergence and maturation of vegetative communities, it is difficult to forecast the degree to which nuisance insects will be an issue. The best approach to avoiding mosquito problems in constructed wetlands is to eliminate areas of open, stagnant water. Flowing water, shaded water, and vegetated areas discourage mosquito larval growth. Removing sticks, branches, or fallen vegetation that inhibits free hydrological movement between deep pools or that block the outlet snout will help keep water freely flowing throughout the system.

Other insect larvae that naturally occur in wetlands, such as those of dragonflies, prey on mosquito larvae. Tree swallows and bats can eat thousands of adult mosquitoes every day. Adding bird or bat habitats can reduce the numbers of adult mosquitoes significantly. The Pumpkinseed (Lepomis gibbosus) is a small sunfish, native to Massachusetts, that feeds primarily on insects, also feeding on crustaceans, very small fish, and aquatic vegetation.

If these strategies fail to adequately curb the nuisance of mosquito populations breeding in the constructed wetland, insecticides, oils, or bacterial agents can be used, although the effects on the wetland and downstream ecosystems are not well understood, and these methods should be used only

as a last resort. Bacillus thuringiensis isroelensis (Bti) is a group of bacteria that can be used as a biological control agent, killing the larvae of various species of mosquito, gnat, and black fly.

7. LONG-TERM POLLUTION PREVENTION MEASURES

Long-term pollution prevention measures implemented at the site reduce pollutants in stormwater discharges. The following precautions will be employed on an on-going basis.

Spill Prevention & Control Measures

To minimize the risk of spills or other accidental exposure of materials and substances to stormwater runoff, the following material management is to be used when working on site.

- Any materials stored on-site will be stored in a neat, orderly manner in their appropriate containers.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Manufacturers' recommendations for proper use and disposal will be followed.
- The contractor's supervisor will be issued this Guide to ensure proper use and disposal of materials.

Materials or substances listed below may be present on-site for maintenance and care should be taken to avoid spills:

  - Petroleum Based Products

The following product-specific measures will be followed on-site:

- *Petroleum Products* - All on-site vehicles will be monitored for leaks and receive preventative maintenance to reduce the chance of leakage.
- *Grass Clipping, Leaf Litter and Plant Debris* – are to be removed from the property and not disposed on site.

APPENDIX A – Maintenance Checklists

- Constructed Wetland

Operation and Maintenance Checklist
Curve Hill Road Stormwater Retrofit Project

Date:

Time:

Inspector:

*Sediment shall be disposed of offsite in a pre-approved location.

Maintenance Item	Description	Maintenance (Y/N)
1. COLLECT **Includes:** Pipe Inlet Area, Drop Inlet **Frequency:** Inspect four times per years during regular park maintenance and after major storm events (2" of rain or greater) **When:** March, June, September, November		
Surface Debris Cleaning	Remove all trash, leaf litter and inlet clogging.	
Inlets	Check for clogging and sediment accumulation that impacts inflow. If sediment/debris accumulation is observed, remove and dispose.	
Actions to be taken:		
2. CAPTURE **Includes:** Water Quality Unit **Frequency:** Inspect four times per year and after major storm events the first year; then annually and after major storm events (2" of rain or greater) **When:** March, June, September, November		
Debris Cleanout	Remove all trash and debris.	
Side Slopes	Signs of erosion gullies, animal burrowing, overtopping, or slumping are observed. Repair, as necessary.	
Sediment/Organic Debris Removal	Remove sediment accumulation and properly dispose when accumulation is greater than or equal to 3 inches or you cannot see stones.*	
Actions to be taken:		
3 & 4. MOVE & FILTER **Includes:** Low Marsh with Permanent pools and Micropools **Frequency:** Inspect four times per year during regular park maintenance and after major storm events (2" of rain or greater) **When:** March, June, September, November		

Operation and Maintenance Checklist
Curve Hill Road Stormwater Retrofit Project

Maintenance Item	Description	Maintenance (Y/N)
Debris Cleanout	Remove trash and debris from the wetland. Remove any fallen branches that prevent free hydraulic movement between the micropools.	
Sediment/Organic Debris Removal	Remove and properly dispose of when build-up is greater than or equal to 3 inches.*	
Erosion	Check for areas of erosion/ gullies, particularly along the steep slopes. Repair/reseed as necessary	
Vegetation Maintenance Replacement	See Landscape Maintenance	
Actions to be taken:		
5. OVERFLOW **Includes:** Emergency Spillway **Frequency:** Inspect bi-annually and after major storm events (2" of rain or greater) **When:** March and September		
Emergency Spillways	Water level should be below the spillway. Check for sediment accumulation that impacts outflow. Check for leaf litter, debris, and inlet clogging. If sediment, litter or debris has accumulated, schedule cleaning.	
Actions to be taken:		
Other Routine Grounds Maintenance **Includes:** Surrounding landscape beyond the practice. **Frequency:** Inspect four times per year during regular park maintenance and after major storm events **When:** March, June, September, November		
Debris Removal	Remove trash from perimeter areas.	
Contributing drainage area	Look for sediment sources from erosion in the surrounding area.	
Drainage Network	Ensure proper operation.	
Path Repairs	Check path for ponding and other obstructions. Repair paths as needed to ensure positive drainage. Remove obstructions as needed.	
Pavement Sweeping	Sweep the access road and parking lot once a year after spring thaw.	
Actions to be taken:		

Operation and Maintenance Checklist
Curve Hill Road Stormwater Retrofit Project

Maintenance Item	Description	Maintenance (Y/N)

Plantings Maintenance Checklist
Curve Hill Road Stormwater Retrofit Project

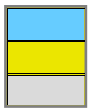
Location:

Date:

Inspector:

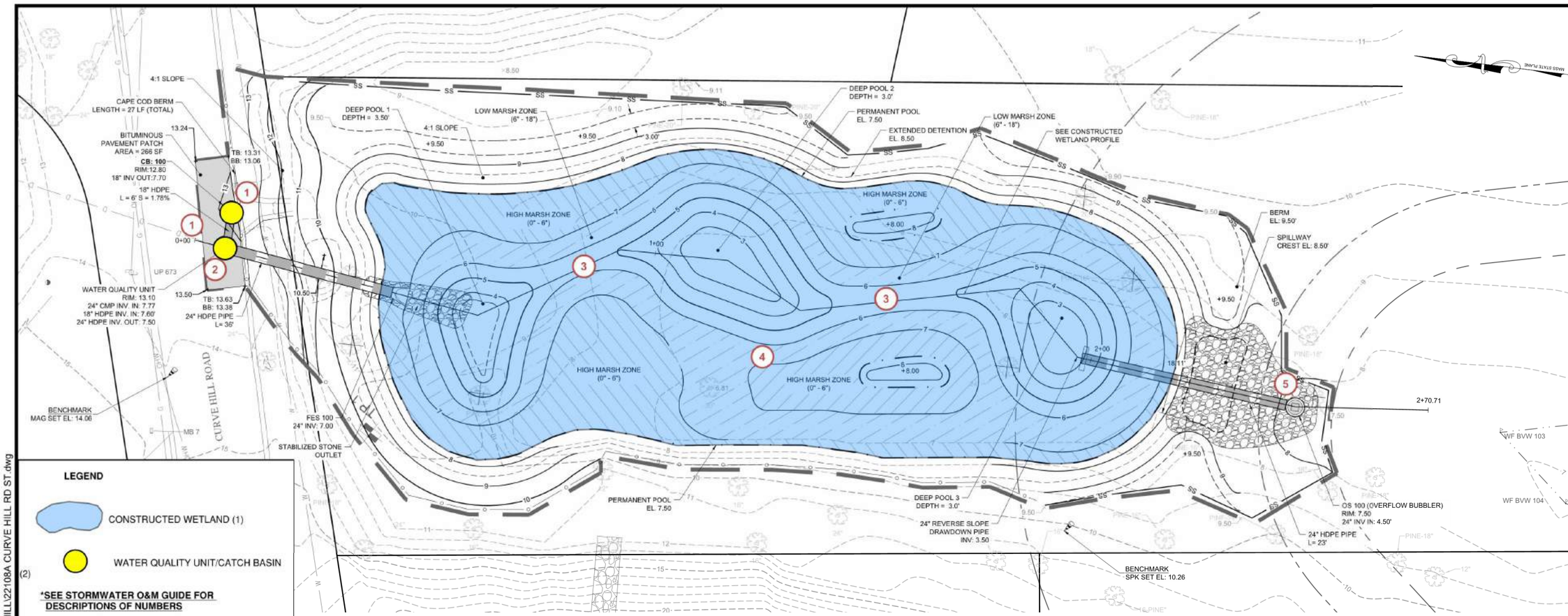
Task	Description	Complete (Y/N)
Cutting	• Cut with shears as desired once a year in the early spring. • Do not cut lower than 6". • Blow out leaves and cuttings for easy removal. • Remove cuttings.	
Weeding	• Weeding should be limited to invasive and exotic species, which can overwhelm the desired plant community.* • Non-chemical methods including hand pulling and hoeing are recommended. • Chemical herbicides are not allowed.	
Monitoring	• Look for potential invasive species and identify potential disease. Remove and dispose of all invasive species.* (see weeding)	
Watering	• During establishment or drought conditions, plants should be watered a minimum of once every seven to ten days.	
Seeding	• Loam and re-seed bare spots with the specified seed mix as shown on the Planting Plan.	
Plant Replacement	• Replace/replant diseases, unhealthy or dead plans to maintain a healthy plant community	
Fertilizing	NONE	
Mulch	NONE	
Debris Removal	• Remove trash from perimeter areas.	
Actions to be taken:		

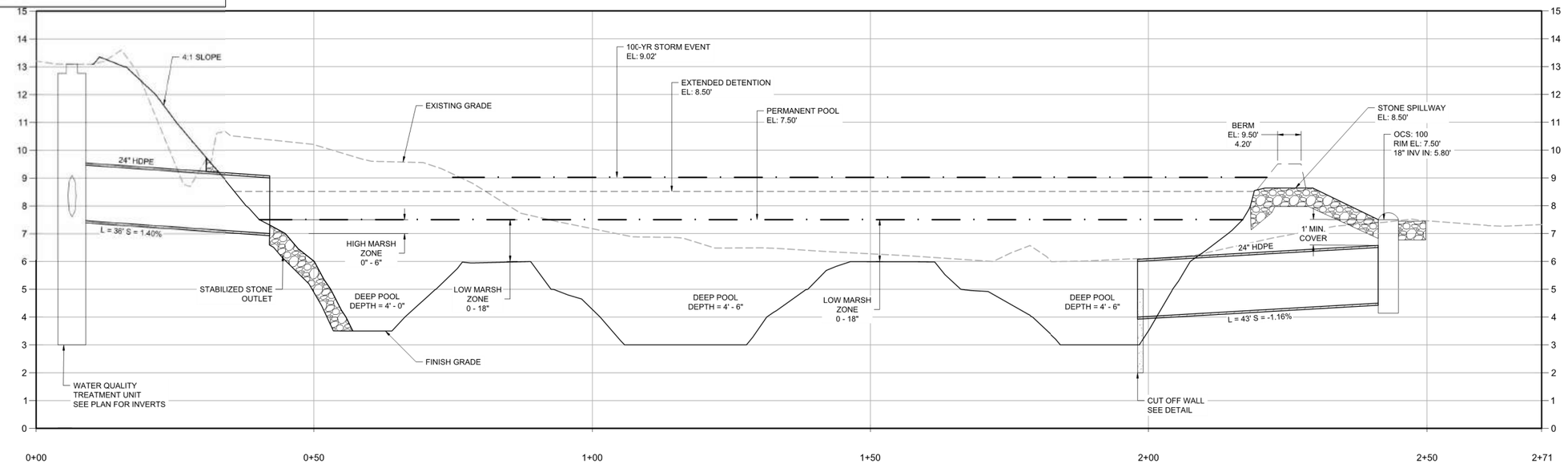
*Invasive species shall be disposed of offsite in a pre-approved location.



Wetland
Wetland Edge
All areas (Wetland and Wetland Edge)

APPENDIX B – Overall SCM Locations





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CONSTRUCTED WETLAND PROFILE
HORIZONTAL SCALE: 1" = 10'
VERTICAL SCALE: 1" = 2'

GRAPHIC SCALE
10 0 5 10 20 40
(in feet)
1 INCH = 10 FEET

Revisions

Rev.	Date	By	Appr	Description

Horsley Witten Group, Inc.
Sustainable Environmental Solutions
www.HorsleyWitten.com
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Sandwich, MA 02563
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Checked By: RAC
Drawn By: GSG
Designed By: GLK
Date: AUGUST 2024

Plan Set: SITE UBR #4: CURVE HILL ROAD
STORMWATER RETROFIT DESIGN AND
IMPLEMENTATION PROJECT - 75% DESIGN
YARMOUTH, MASSACHUSETTS

Plan Title: OVERALL SCM LOCATIONS

Prepared For:
Town of Yarmouth
DPW
74 Town Brook Road
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Phone: (508) 398-2231 ext. 1250

Survey Provided By:
Horsley Witten Group, Inc.
90 Route 6A
Sandwich, MA 02536
Phone: 508-833-6600
Fax: 508-833-3150
Dated: January 1, 2024

Registration:

Project Number: 22108
Sheet : 1 of 1

Sheet Number: C - 4

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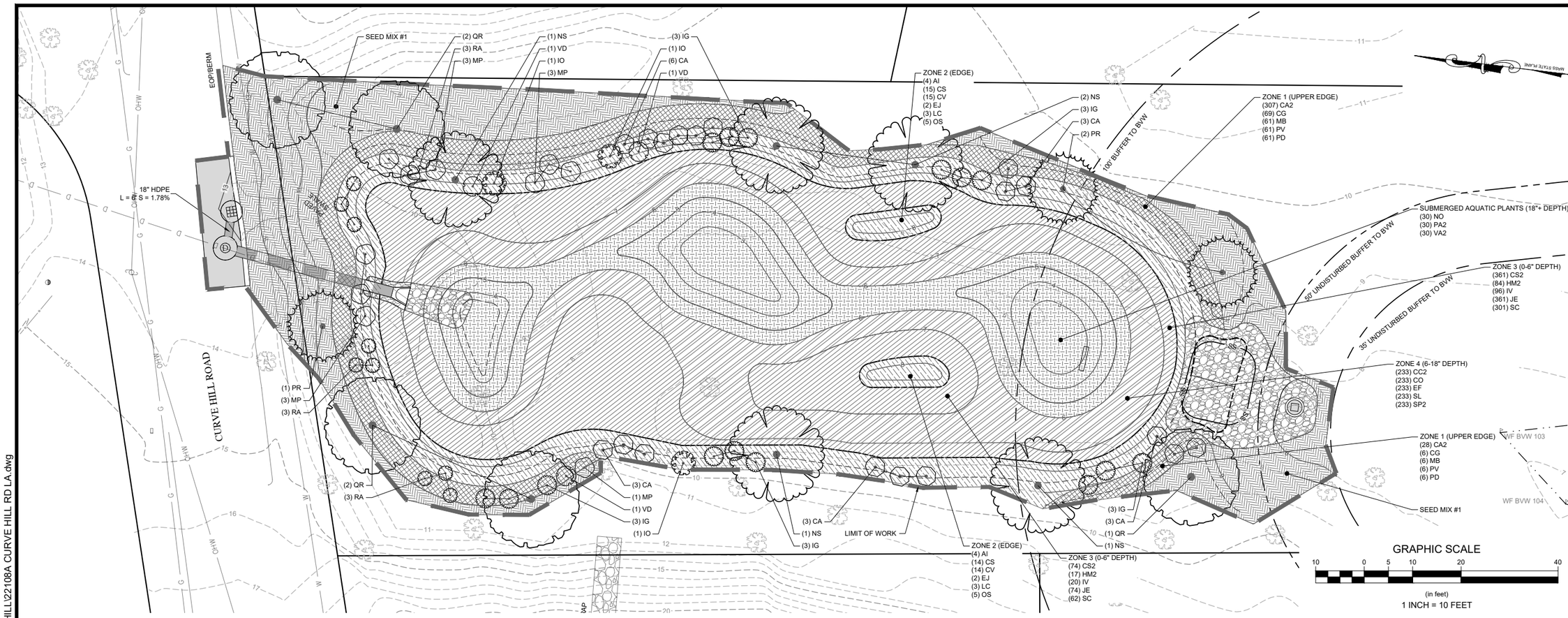
APPENDIX C – Planting Plan



PLANT SCHEDULE

SYMBOL	CODE	QTY	BOTANICAL NAME	COMMON NAME	SIZE	CANOPY
TREES						
	NS	5	Nyssa sylvatica	Tupelo	2" Cal.	20'
	PR	3	Pinus rigida	Pitch Pine	2" Cal.	15'
	QR	5	Quercus rubra	Northern Red Oak	2" Cal.	20'
SHRUBS						
	CA	18	Clethra alnifolia	Summersweet	#5	48" o.c.
	IG	15	Ilex glabra	Inkberry Holly	#5	48" o.c.
	IO	3	Ilex opaca	American Holly	#7	60" o.c.
	MP	10	Myrica pensylvanica	Northern Bayberry	#5	48" o.c.
	RA	9	Rhus aromatica	Fragrant Sumac	#3	36" o.c.
	VD	3	Viburnum dentatum	Viburnum	#5	48" o.c.

SYMBOL	CODE	QTY	BOTANICAL NAME	COMMON NAME	SIZE	SPACING
GROUND COVERS						
		1,453 sf	ZONE 1 (UPPER EDGE)			
	CA2	335	Carex appalachica	Appalachian Sedge	#1	50% @ 18" o.c.
	CG	75	Chelone glabra	White Turtlehead	#1	20% @ 24" o.c.
	MB	67	Monarda fistulosa	Bergamot	#1	10% @ 18" o.c.
	PV	67	Panicum virgatum	Switch Grass	#1	10% @ 18" o.c.
	PD	67	Penstemon digitalis	Beardtongue	#1	10% @ 18" o.c.
		2,484 sf	ZONE 2 (EDGE)			
	AI	92	Asclepias incarnata	Swamp Milkweed	#1	8% @ 18" o.c.
	CS	344	Carex stipata	Awl-fruited Sedge	#1	30% @ 18" o.c.
	CV	344	Carex vulpinoidea	Fox Sedge	#1	30% @ 18" o.c.
	EJ	57	Eupatorium fistulosum	Hollow Joe Pye Weed	#1	5% @ 18" o.c.
	LC	80	Lobelia cardinalis	Cardinal Flower	#1	7% @ 18" o.c.
	OS	128	Onoclea sensibilis	Sensitive Fern	#1	20% @ 24" o.c.
		3,139 sf	ZONE 3 (0-6" DEPTH)			
	CS2	435	Carex stricta	Tussock Sedge	#1	30% @ 18" o.c.
	HM2	101	Hibiscus moscheutos	Rose Mallow	#1	7% @ 18" o.c.
	IV	116	Iris versicolor	Blue Flag	#1	8% @ 18" o.c.
	JE	435	Juncus effusus	Soft Rush	#1	30% @ 18" o.c.
	SC	363	Scirpus cyperinus	Wool Grass	#1	25% @ 18" o.c.
		2,519 sf	ZONE 4 (6-18" DEPTH)			
	CC2	233	Carex comosa	Longhair Sedge	#1	20% @ 18" o.c.
	CO	233	Cephalanthus occidentalis	Buttonbush	#1	20% @ 18" o.c.
	EF	233	Equisetum fluviale	Horsetail Reed Grass	#1	20% @ 18" o.c.
	SL	233	Sagittaria latifolia	Broadleaf Arrowhead	#1	20% @ 18" o.c.
	SP2	233	Scirpus pungens	Three Square Bulrush	#1	20% @ 18" o.c.
		2,626 sf	SUBMERGED AQUATIC PLANTS (18"+ DEPTH)			
	NO	30	Nymphaea odorata	Fragrant Water Lily	3 gal.	33% @ 66" o.c.
	PA2	30	Persicaria amphibia	Water Smartweed	3 gal.	34% @ 67" o.c.
	VA2	30	Vallisneria americana	American Eelgrass	3 gal.	33% @ 66" o.c.

SYMBOL	QTY	BOTANICAL NAME	COMMON NAME
GROUND COVERS			
	2,751 sf	SEED MIX #1: STABILIZER ROADSIDE & EROSION CONTROL MIX	
		Agrostis perennans	Autumn Bentgrass
		Andropogon gerardii	Big Bluestem
		Asclepias tuberosa	Butterfly Milkweed
		Carex swanii	Swan's Sedge
		Chamaecrista fasciculata	Partridge Pea
		Coreopsis lanceolata	Lanceleaf Tickseed
		Deschampsia flexuosa	Crinkled Hair Grass
		Desmodium canadense	Showy Tick Trefoil
		Elymus canadensis	Canada Wild Rye
		Festuca x Schizachyrium scoparium	Rough Bent Grass/Blue Hard Fescue / Little Bluestem
		Solidago sempervirens	Seaside Goldenrod
		Trifolium repens	White Clover

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NOT FOR CONSTRUCTION

Revisions

Rev.	Date	By	Appr	Description

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Checked By: MBE
Drawn By: KJK
Designed By: KJK/MBE
Date: AUGUST 2024

Plan Set: SITE UBR #4: CURVE HILL ROAD STORMWATER RETROFIT DESIGN AND IMPLEMENTATION PROJECT - 75% DESIGN YARMOUTH, MASSACHUSETTS

Plan Title: PLANTING PLAN

Prepared For:
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Fax: 508-833-3150
Dated: January 1, 2024

Registration:

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Project Number: 22108
Sheet: 6 of 7
Sheet Number: L - 1

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APPENDIX E – Pollutant Controls During Construction

POLLUTANT CONTROLS DURING CONSTRUCTION

1.1 Structural Practices

The following are the structural practices that will be implemented as part of the construction activity.

- Sediment Silt Sock Barrier will be installed prior to commencement of construction. The silt sock will be used on the downgradient portions of the limit of work to allow water to flow through it while keeping sediment on site. The Town will be informed upon their installation so that they may inspect these barriers prior to construction. Portions of these barriers will be replaced and/or repaired as necessary. Barriers will be installed parallel to land slope at the perimeter of the work site, as shown on the Plans. Details are provided in the Plans.

- Silt Sacks (or approved equivalent) will be installed at catch basins and following construction of the proposed overflow structures to prevent sedimentation during construction. The silt sack will be emptied/replaced and disposed of off-site if damage is observed.

- Sediment Traps/Basins. The water quality unit, catch basin, and inlet pipe into the constructed wetland will be installed first, so that sediment from the roadways is captured by the water quality unit before discharging onto the site. The constructed wetland will be dewatered during construction activities from . Heavy equipment will not be allowed to operate on the surface location where the system is planned because soil compaction can adversely impact the long-term performance. Light earth-moving equipment will be used for excavation and construction of the system. All excavated materials from the area will be removed and disposed of in an approved location.

- Construction Entrance will be installed. All construction vehicles must use this access point to ensure sediment is not tracked off site.

- Slope Stabilization will occur immediately upon obtaining final grades as shown on the project site plans. Areas that fail to stabilize will be re-graded to final grade and stabilized as necessary. The amount of land disturbed will be minimized to reduce potential for erosion and sedimentation. Stabilization measures shall be initiated within 14 days following the end of construction at each portion of the site and as soon as practicable.

The entire stormwater management system including pipes, structures, and constructed wetland, will be inspected upon completion of construction. Sediment will be removed from all elements of the stormwater management system. All control measures must be installed and maintained in accordance with manufacturer's specifications, good engineering practices, and in accordance with this report (every seven calendar days and after storm events). If inspections show that a control has failed or been installed incorrectly, the Operator must replace or modify it within 24 hours.

1.2 Stabilization Practices

The amount of land disturbed during construction will be minimized to reduce the potential for erosion and sedimentation. Prompt surface stabilization will be provided to control erosion in areas where disturbances cannot be avoided during construction. Stabilization measures shall be initiated within 14 days following the end of construction at each portion of the site. Exceptions to this requirement are allowable when snow cover prevents the initiation of stabilization within 14 days, in which case such measures shall be undertaken as soon as possible.

Stabilization measures that will be, or may be, used during construction are described below:

- Temporary Seeding – Temporary seeding of disturbed surfaces with fast-growing grasses (annual rye) to provide greater resistance to stormwater runoff and/or wind erosion for areas where construction has temporarily ceased.
- Permanent Seeding – Permanent seeding of surfaces with vegetation, including but not limited to grass, trees, bushes, and shrubs, to stabilize the soil. Establishing a permanent and sustainable ground cover at a site stabilizes the soil while reducing the sediment content in runoff.
- Permanent Planting –establish all planting as required at the completion of the project.
- Erosion Control Blankets - install erosion control blankets along all slopes greater than 3:1.
- Mulching – materials, including but not limited to hay, grass, woodchips, straw, and gravel will be placed on the soil surface to cover and hold in place disturbed soils.

Temporary seeding or other soil stabilization measures will be provided where construction activities have ceased at the site. Topsoil stockpiles will be temporarily seeded or covered to prevent erosion and will be surrounded with silt fence or silt sock. When the site's final grade has been established, permanent vegetation will be planted on the disturbed areas. The vegetation will consist of grass, shrubs, bushes, and trees in the locations indicated on the plans.

1.3 Other Types of Controls

Additional controls/practices will be undertaken to reduce pollution in stormwater runoff flows which include, but are not limited to, control of off-site mud tracking from construction site, dust suppression, proper sanitary waste disposal, earthwork procedures timed and conducted in manners aimed to minimize erosion and sedimentation, snow removal plans, proper management of waste materials, proper management of hazardous waste, proper material stockpiling, and spill prevention and control measures.

- Dust Suppression – Water sprays shall be used to control dust during extended dry periods during construction.

- Earthwork – The exposure of disturbed surfaces to stormwater and potential stormwater erosion will be minimized by well-organized earthwork procedures. Stabilization procedures shall be undertaken in accordance with this report. Grubbing during wet seasons will be avoided if feasible.

- Snow Removal Plan – Plowed snow collected from the roadway and parking areas will be deposited onto free draining, pervious surfaces, away from the sites drainage conveyance structures to maximize infiltration.

- Waste Materials – Dumpsters rented from a licensed solid waste management company will be used to store solid waste and debris that cannot be recycled, reused or salvaged. The dumpsters will meet all local and state solid waste management regulations. Dumpsters will be covered when refuse is not being directly deposited or withdrawn from them. Potentially hazardous wastes will be separated from normal wastes, including segregation of storage areas and proper labeling of containers. Removal of all waste from the site will be performed by licensed contractors in accordance with applicable regulatory requirements and disposed of at either local or regional approved facilities. Waste materials will not be buried on-site. All site personnel will be instructed regarding the correct procedures for waste disposal. Notices stating these procedures will be posted at the site. Solvents and flushing materials used during construction and pre-operational cleaning will be provided, handled, managed, and removed by the contractor for appropriate off-site disposal.

- Hazardous Waste Materials – Any disposal of hazardous materials will be completed using the required paperwork. Copies will be provided to the Engineer and to the city.

- Spill Prevention and Control Measures – To minimize the risk of spills or other accidental exposure of materials and substances to stormwater runoff, the following material management practices will be used throughout the project:

    - An effort will be made to store only enough products required to do the job.

    - All materials stored on-site will be stored in a neat, orderly manner in their appropriate containers and, if possible, under a roof or other enclosure.

    - Products will be kept in their original containers with the original manufacturer's label.

    - Substances will not be mixed with one another unless recommended by the manufacturer.

    - Whenever possible, the maximum amount of a product will be used before disposing of the container.

    - Manufacturers' recommendations for proper use and disposal will be followed.

- The site superintendent will conduct daily inspections to ensure proper use and disposal of materials.

To reduce the risk associated with hazardous materials used on the site, the following practices will be used:

- Products will be kept in original containers unless they are not resealable.
- Original labels and material safety data sheets will be retained and kept on-site; they contain important product information.
- If surplus product must be disposed of, manufacturers' or local and state recommended methods for proper disposal will be followed.

- Materials List - Materials or substances listed below are expected to be present on-site during construction:

- Concrete	- Fertilizers
- Asphalt	- Petroleum Based Products
- Paints (enamel and latex)	- Cleaning Solvents
- Metal Studs	- Wood
- Concrete	- Tar
- Sealants	- Adhesives

The following product-specific practices will be followed on-site:

Petroleum Products - All on-site vehicles will be monitored for leaks and receive preventative maintenance to reduce the chance of leakage. Petroleum products will be stored in tightly sealed containers which area clearly labeled. Any asphalt substances used on-site will be applied according to the manufacturers' recommendations.

Paints – All containers will be tightly sealed and stored indoors when not required for use. Excess paint will not be discharged to the storm sewer system but will be properly disposed of according to the manufacturers' instructions or state and local regulations.

Concrete Trucks – Concrete trucks will not be allowed to wash out or discharge surplus concrete or drum wash water on the site.

In addition to the good housekeeping and material management practices discussed in the previous sections of this plan, the following practices will be followed for spill prevention and cleanup:

- Manufacturers' recommended methods for spill cleanup will be clearly posted, and site personnel will be made aware of the procedures and location of the information and cleanup supplies.

- Materials and equipment necessary for spill cleanup will be kept in the material storage area on-site. Equipment and materials will include, but not be limited to, brooms, dust pans, mops, rags, gloves, goggles, speedi-dry, sand, sawdust, and plastic and metal trash containers specifically for this purpose.

- All spills will be cleaned up immediately after discovery. Spills large enough to reach the storm water system will be reported to the National Response Center at 1-800-424-8802.

- The spill area will be kept well ventilated and personnel will wear appropriate protective clothing to prevent injury from contact with a hazardous substance.

- Spills of toxic or hazardous material will be reported to the appropriate state or local government agency, regardless of the size.

- The site superintendent responsible for the day-to-day site operations will be the spill prevention and clean-up coordinator. He will designate at least three other site personnel who will receive spill prevention and cleanup training. These individuals will each become responsible for a particular phase of prevention and cleanup. The names of responsible spill personnel will be posted in the material storage area and in the on-site office trailer.

APPENDIX F – Site Plans