Stamski and McNary, Inc.
Engineering - Planning – Surveying
1000 Main Street; Acton, MA 01720 (978) 263-8585

Stormwater Management Report

for

493 Massachusetts Avenue
Parcel 15-002-000
Boxborough, MA

Owner/Applicant: Acton-Boxborough Regional School District
16 Charter Road
Acton, MA 01720

Date: January 30, 2019

Job No. SM-1323

Drainage Analysis and Design

Checklist for Stormwater Report

Narrative

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Checklist for Stormwater Report

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

Checklist for Stormwater Report

A. Introduction

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

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

The Stormwater Report must include:

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

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

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

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature

COMMONWEALTH OF MASSACHUSETTS
GEORGE
DIMAKARAKOS
CIVIL
No. 41281
REGISTERED
PROFESSIONAL ENGINEER

1/29/19

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): Subsurface Chambers, Proprietary Separator

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.

Narrative

Stormwater Management

The proposed project is for the construction of a stormwater management system to serve an expanded parking lot that was constructed without a permit.

Pre-Development

The existing 8.37± ac. site is within the Agricultural/Residential Zoning and contains an existing public elementary school with associated parking lot and fields. An expansion to the parking lot was constructed before a field survey was conducted. Aerial photographs and the visible extent of the original pavement (located via field survey) served as the basis of the predevelopment drainage analysis. Prior to the construction of the parking lot, the entirety of the newly disturbed area was lawn.

Subcatchment E-1 contains much of the grass field and the area between the previous extent of pavement and a Bordering Vegetated Wetland (B.V.W.) located to the west of the property. Prior to construction of the expanded parking lot, there was a 10'-wide concrete walkway that followed along the side of the entrance driveway. Cover within this subcatchment consists of the concrete walkway, lawn, and wooded area. Runoff from this subcatchment drained to the B.V.W. to the west of the property.

Post Development

The proposed project is for the construction of a stormwater management system to serve the expanded paved area. The proposed stormwater management system has been designed for the 2, 10, and 100-year storms. The proposed subcatchments are shown on the attached drainage map.

Subcatchment P-1 consists of the majority of the area within Subcatchment E-1. The pavement along the driveway was expanded to create parallel parking spaces. A 5'-wide concrete walk was also built along the edge of the expanded paved area to replace the original walkway. Runoff from this subcatchment drains to an existing catch basin which was originally located along the gutter line but is now in the middle of the driveway. Runoff from this subcatchment will continue to flow into the existing catch basin. A Contech treatment unit is proposed off the edge of the walkway to treat runoff entering the catch basin before it is discharged via an existing outlet pipe to the B.V.W. located to the west of the property.

Subcatchment P-2 contains the newly constructed parking area and lawn area. An area drain is proposed to collect runoff from the paved area and divert it to subsurface infiltration chambers located approximately 5' from the edge of the pavement.

In accordance with the Town of Boxborough Site Plan Rules and Regulations, Standards 1 through 10 of the Massachusetts Department of Environmental Protection Stormwater Management Standards have been met. In addition, the system design will not result in a

serious flood hazard during the 100-year storm event. The peak runoff rates have been summarized in the following tables.

Compliance with MA DEP Stormwater Management Standards

Compliance with the Stormwater Management Standards is as follows:

Standard 1: No Untreated Discharges
No untreated discharges to wetlands are proposed. Additional runoff from the site is to be treated with a Contech treatment unit, grass and gravel combination, deep sump basin, and subsurface infiltration chambers.

Standard 2: Peak Rate Attenuation
The Post-Development peak discharge rates must not be increased from pre-development rates for the 2-year, 10-year, and 100-year storm events. Also, offsite flood impact from the 100-year storm must not be increased. Using subsurface infiltration chambers, the peak runoff rate and volume have been decreased. The peak runoff rates have been summarized in the following tables.

Discharge Summary Tables

Total Runoff – To B.V.W.

	2-year Storm		10-year Storm		100-year Storm	
	Pre	Post	Pre	Post	Pre	Post
Peak Flow (cfs)	0.001	0.000	0.034	0.021	0.579	0.386
Total Volume (cf)	11.9	0.000	893	571	4,094	3,085

Standard 3: Stormwater Recharge
The subsurface infiltration chambers have been sized to infiltrate the required recharge volume using the Simple Dynamic Method. Detailed calculations showing compliance with Standard 3 have been attached to this report.

Standard 4: Water Quality
The required water quality volume for this project is 1" of runoff over the impervious area for the infiltration. This volume will be treated to meet the 80% TSS removal requirement of the Standard via the use of a Contech treatment unit in Subcatchment P-1. A grass and gravel combination and deep sump area drain to achieve 44% pretreatment are proposed within Subcatchment P-2. The area treated is greater than the amount of increased impervious surface on the site. Calculations showing treatment levels are attached.

Standard 5: Land Uses with Higher Potential Pollutant Loads
The site proposed will not contain "land uses with higher potential pollutant loads."

Standard 6: Critical Areas
The site is not located within an Interim Wellhead Protection Area. Pretreatment and infiltration BMP's have been selected in accordance with Table CA 3 of the Massachusetts Stormwater Handbook.

Standard 7: Redevelopment
The proposed project is not redevelopment.

Standard 8: Construction Period Controls
The erosion and sedimentation control measures will be followed in accordance with the requirements of the NPDES Construction General Permit. The project will require coverage under the NPDES Construction General Permit.

Standard 9: Operation and Maintenance Plan
An Operation and Maintenance Plan is included in this report.

Standard 10: Illicit Discharges to Drainage System
An Illicit Discharge Compliance will be provided prior to the discharge of stormwater runoff to the post-construction stormwater BMP's.

Design Basis

1. The United States Department of Agriculture Natural Resource Conservation Service (N.R.C.S.) TR55 methodology was used to determine offsite rates of runoff.
2. The twenty-four hour rainfall, taken from N.R.C.S. publications, is 6.5 inches for the 100-year storm, 4.5 inches for the 10-year storm, and 3.1 inches for the 2-year storm event.
3. The hydrologic calculations were performed using the computer program: "Hydrology Studio" by Hydrology Studio.
4. The soil types of the site were taken from the N.R.C.S. Soil Survey Map for Middlesex County.
5. Soil conditions and estimated seasonal high groundwater table were based on on-site soil evaluations.
6. The Natural Resources Conservation Service (N.R.C.S.) soil survey indicated the presence of Hinckley loamy sand. On-site soil evaluations determined that the soil underlying the drainage is loamy-sand, corresponding to Hydrologic Group A.

Pre-Development Hydrology

Hydrograph 2-yr Summary

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	E-1	0.001	22.13	11.9	---		
3	NRCS Runoff	P-1	0.00	0.00	0.000	---		
4	NRCS Runoff	P-2	0.298	12.07	893	---		
5	Pond Route	Subsurface Chambers	0.000	14.93	0.000	4	240.98	196
6	Junction	POST TOTAL	0.000	14.93	0.000	3, 5		

Hydrograph 10-yr Summary

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	E-1	0.034	13.73	893	---		
3	NRCS Runoff	P-1	0.021	14.77	571	---		
4	NRCS Runoff	P-2	0.540	12.07	1,615	---		
5	Pond Route	Subsurface Chambers	0.000	16.63	0.000	4	241.40	510
6	Junction	POST TOTAL	0.021	14.77	571	3, 5		

Hydrograph 100-yr Summary

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	E-1	0.579	12.30	4,094	----		
3	NRCS Runoff	P-1	0.386	12.33	3,085	----		
4	NRCS Runoff	P-2	0.898	12.07	2,726	----		
5	Pond Route	Subsurface Chambers	0.000	11.27	0.000	4	242.29	1,037
6	Junction	POST TOTAL	0.386	12.33	3,085	3, 5		

Worksheet 2: Runoff curve number and runoff SM-1323

Project: 493 Massachusetts Avenue By PFK Date 1/28/2019

Location: Boxborough, MA Checked _____ Date _____

Circle one: [Present] Developed E-1

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition: percent impervious: unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area Acres	Product of CN x Area
-	Impervious	98			0.07	6.69
A	Open Space-Good Condition	39			0.62	24.00
A	Woods- Good Condition	30			0.72	21.65
A	Gravel Drive	76			0.00	0.00
C	Open Space-Good Condition	74			0.00	0.00
C	Woods- Good Condition	70			0.00	0.00
C	Gravel Drive and Cartpath	89			0.00	0.00
A	Dirt (Parking Area and Field)	72			0.15	10.83
				Totals =	1.56	63.17

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{63.17}{1.56} = 40.61$; Use CN = 40.6

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	10	100
Rainfall, P (24-hour)	in	3.1	4.5	6.4
Runoff, Q (Use P and CN with table 2-1, fig. 2-1,) or eqs. 2-3 and 2-4.)	in	0.00	0.15	0.67
Runoff, Q	cf	12	864	3767

D-2 (210-VI-TR-55, Second Ed., June 1986)

Worksheet 3: Time of Concentration (Tc) or travel time (Tt) SM-1323

Project: 493 Massachusetts Avenue By PFK Date 1/28/2019

Location: Boxborough, MA Checked _____ Date _____

Circle one: Present Developed
Circle one: Tc Tt through subarea E-1

Sheet flow (Applicable to Tc only)		Segment ID	A-B			
1. Surface Description (table 3-1)			LAWN			
2. Mannings roughness coeff., n (table 3-1)			0.24			
3. Flow length, L (total L <= 300 ft)		ft	50			
4. Two-yr 24-hr rainfall, P2		in	3.1			
5. Land Slope, s		ft/ft	0.01			
6. Tt = 0.007 (nL)^0.8 / (P2^0.5 s^0.4)	Compute Tt	hr	0.18			0.18
Shallow concentrated Flow		Segment ID	C-D			
7. Surface Description (paved or unpaved)			UNPAVED			
8. Flow Length, L		ft	198			
9. Watercourse slope, s		ft/ft	0.02			
10. Average Velocity, V (figure 3-1)		ft/s	2.28			
11. Tt = L / 3600V	Compute Tt	hr	0.02			0.02
Channel flow		Segment ID				
12. Cross sectional flow area, a		sf				
13. Wetted perimeter, pw		ft				
14. Hydraulic radius, r=a/wp	Compute r	ft				
15. Channel Slope, s		ft/ft				
16. Manning's roughness coeff., n						
17. V = 1.49 r^2/3 s^1/2 / n	Compute V	ft/s				
18. Flow length, L		ft				
19. Tt = L / 3600V	Compute Tt	hr				0.00

20. Watershed or subarea Tc or Tt (add Tt in steps 6, 11, and 19) hr 0.21
min 12.4

(210-VI-TR-55, Second Ed., June 1986)

Hydrograph Report

Project Name:

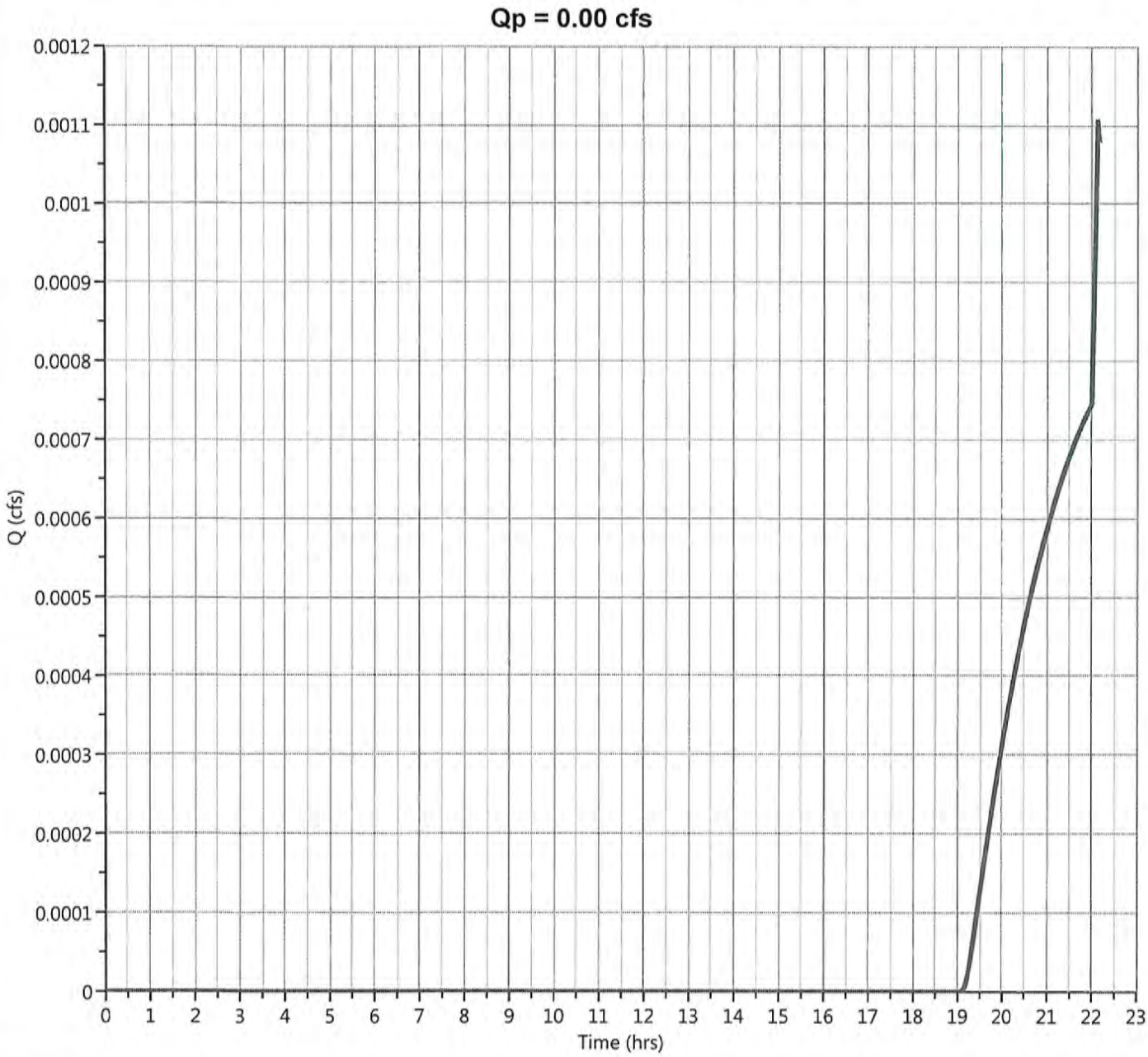
Hydrology Studio v 1.0.0.0

01-29-2019

E-1

Hyd. No. 1

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.001 cfs
Storm Frequency	= 2-yr	Time to Peak	= 22.13 hrs
Time Interval	= 2 min	Runoff Volume	= 11.9 cuft
Drainage Area	= 1.56 ac	Curve Number	= 40.6
Tc Method	= User	Time of Conc. (Tc)	= 12.4 min
Total Rainfall	= 3.1000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Hydrograph Report

Project Name:

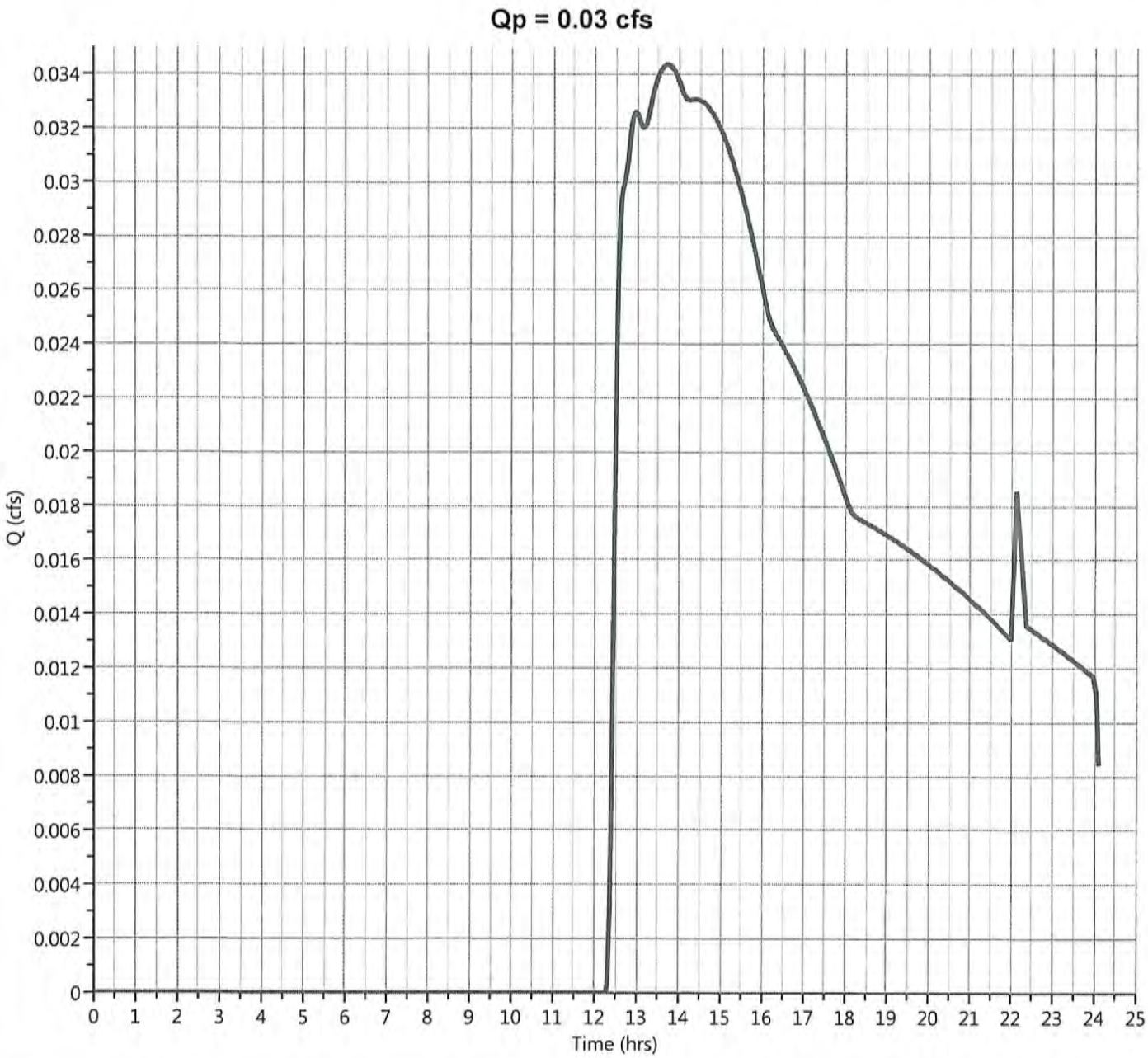
Hydrology Studio v 1.0.0.0

01-29-2019

E-1

Hyd. No. 1

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.034 cfs
Storm Frequency	= 10-yr	Time to Peak	= 13.73 hrs
Time Interval	= 2 min	Runoff Volume	= 893 cuft
Drainage Area	= 1.56 ac	Curve Number	= 40.6
Tc Method	= User	Time of Conc. (Tc)	= 12.4 min
Total Rainfall	= 4.5000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Hydrograph Report

Project Name:

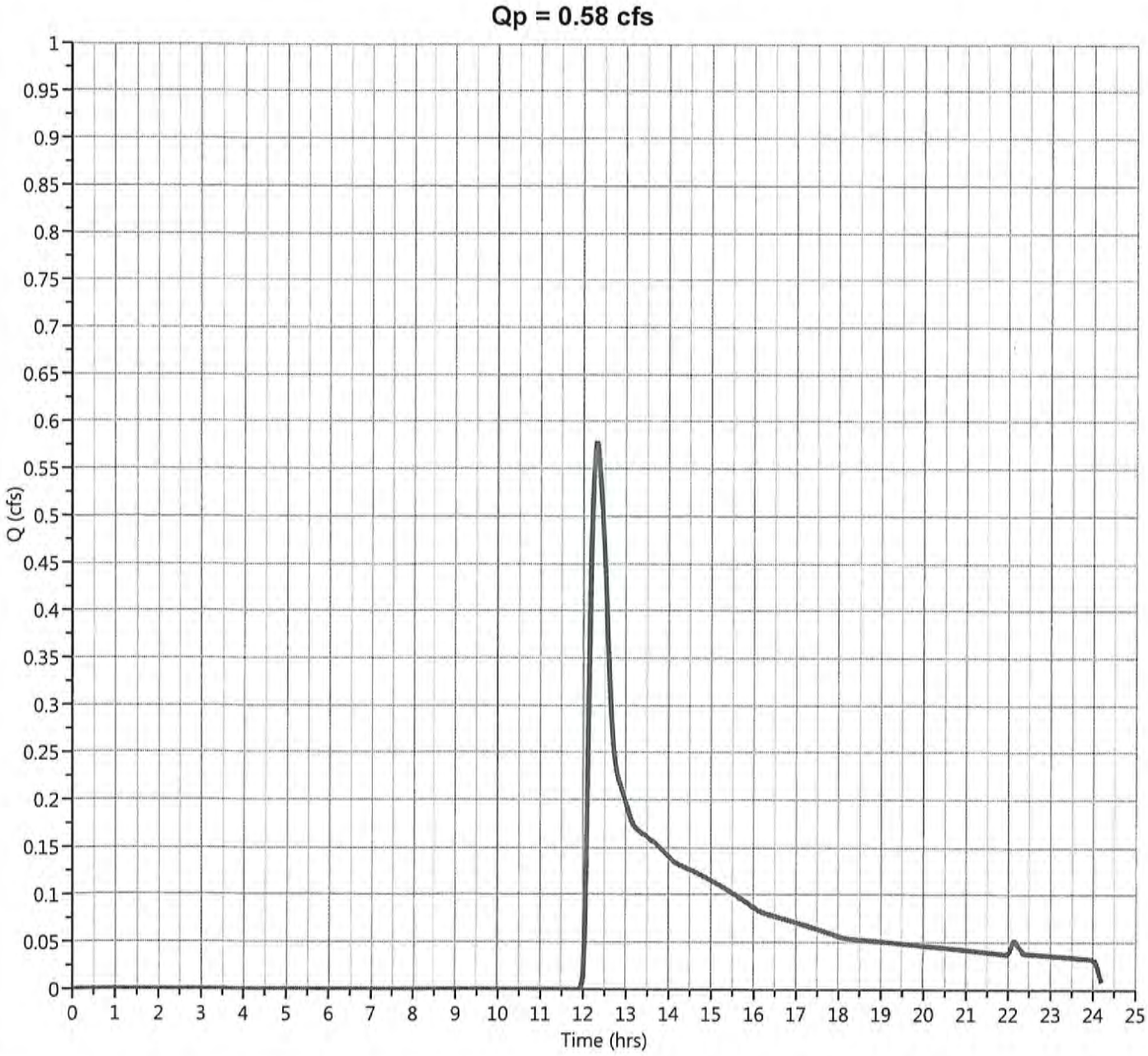
Hydrology Studio v 1.0.0.0

01-29-2019

E-1

Hyd. No. 1

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.579 cfs
Storm Frequency	= 100-yr	Time to Peak	= 12.30 hrs
Time Interval	= 2 min	Runoff Volume	= 4,094 cuft
Drainage Area	= 1.56 ac	Curve Number	= 40.6
Tc Method	= User	Time of Conc. (Tc)	= 12.4 min
Total Rainfall	= 6.5000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Post-Development Hydrology

Hydrograph 2-yr Summary

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	E-1	0.001	22.13	11.9	----		
3	NRCS Runoff	P-1	0.00	0.00	0.000	----		
4	NRCS Runoff	P-2	0.298	12.07	893	----		
5	Pond Route	Subsurface Chambers	0.000	14.93	0.000	4	240.98	196
6	Junction	POST TOTAL	0.000	14.93	0.000	3, 5		

Hydrograph 10-yr Summary

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	E-1	0.034	13.73	893	----		
3	NRCS Runoff	P-1	0.021	14.77	571	----		
4	NRCS Runoff	P-2	0.540	12.07	1,615	----		
5	Pond Route	Subsurface Chambers	0.000	16.63	0.000	4	241.40	510
6	Junction	POST TOTAL	0.021	14.77	571	3, 5		

Hydrograph 100-yr Summary

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Hyd. No.	Hydrograph Type	Hydrograph Name	Peak Flow (cfs)	Time to Peak (hrs)	Hydrograph Volume (cuft)	Inflow Hyd(s)	Maximum Elevation (ft)	Maximum Storage (cuft)
1	NRCS Runoff	E-1	0.579	12.30	4,094	----		
3	NRCS Runoff	P-1	0.386	12.33	3,085	----		
4	NRCS Runoff	P-2	0.898	12.07	2,726	----		
5	Pond Route	Subsurface Chambers	0.000	11.27	0.000	4	242.29	1,037
6	Junction	POST TOTAL	0.386	12.33	3,085	3, 5		

Worksheet 2: Runoff curve number and runoff SM-1323

Project: 493 Massachusetts Avenue By PFK Date 1/28/2019

Location: Boxborough, MA Checked _____ Date _____

Circle one: Present **Developed** P-1

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition: percent impervious: unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area Acres	Product of CN x Area
-	Impervious	98			0.10	9.63
A	Open Space-Good Condition	39			0.52	20.36
A	Woods- Good Condition	30			0.72	21.65
A	Gravel Drive	76			0.00	0.00
C	Open Space-Good Condition	74			0.00	0.00
C	Woods- Good Condition	70			0.00	0.00
C	Gravel Drive and Cartpath	89			0.00	0.00
A	MEADOW	30			0.00	0.00
A	Dirt Field	72			0.04	2.67
				Totals =	1.38	54.31

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}} = \frac{54.31}{1.38} = 39.38$; Use CN = **39.4**

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	10	100
Rainfall, P (24-hour)	in	3.1	4.5	6.4
Runoff, Q (Use P and CN with table 2-1, fig. 2-1,) or eqs. 2-3 and 2-4.)	in	0.00	0.12	0.59
Runoff, Q	cf	0	601	2951

D-2 (210-VI-TR-55, Second Ed., June 1986)

Worksheet 3: Time of Concentration (Tc) or travel time (Tt) SM-1323

Project: 493 Massachusetts Avenue By PFK Date 1/28/2019

Location: Boxborough, MA Checked _____ Date _____

Circle one: Present | Developed

Circle one: Tc | Tt through subarea P-1

		Segment ID	A-B			
Sheet flow (Applicable to Tc only)						
1. Surface Description (table 3-1)			LAWN			
2. Mannings roughness coeff., n (table 3-1)			0.24			
3. Flow length, L (total L <= 300 ft)		ft	50			
4. Two-yr 24-hr rainfall, P2		in	3.1			
5. Land Slope, s		ft/ft	0.01			
6. Tt = 0.007 (nL)^0.8 / (P2^0.5 s^0.4)	Compute Tt	hr	0.18			0.18

		Segment ID	C-D			
Shallow concentrated Flow						
7. Surface Description (paved or unpaved)			UNPAVED			
8. Flow Length, L		ft	210			
9. Watercourse slope, s		ft/ft	0.02			
10. Average Velocity, V (figure 3-1)		ft/s	2.28			
11. Tt = L / 3600V	Compute Tt	hr	0.03			0.03

		Segment ID				
Channel flow						
12. Cross sectional flow area, a		sf				
13. Wetted perimeter, pw		ft				
14. Hydraulic radius, r=a/wp	Compute r	ft				
15. Channel Slope, s		ft/ft				
16. Manning's roughness coeff., n						
17. V = 1.49 r^2/3 s^1/2 / n	Compute V	ft/s				
18. Flow length, L		ft				
19. Tt = L / 3600V	Compute Tt	hr				0.00

20. Watershed or subarea Tc or Tt (add Tt in steps 6, 11, and 19) hr 0.21
min 12.5

(210-VI-TR-55, Second Ed., June 1986)

Hydrograph Report

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

P-1

Hyd. No. 3

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.00 cfs
Storm Frequency	= 2-yr	Time to Peak	= 0.00 hrs
Time Interval	= 2 min	Runoff Volume	= 0.000 cuft
Drainage Area	= 1.38 ac	Curve Number	= 39
Tc Method	= User	Time of Conc. (Tc)	= 12.5 min
Total Rainfall	= 3.1000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484

Qp = 0.00 cfs

Hydrograph Report

Project Name:

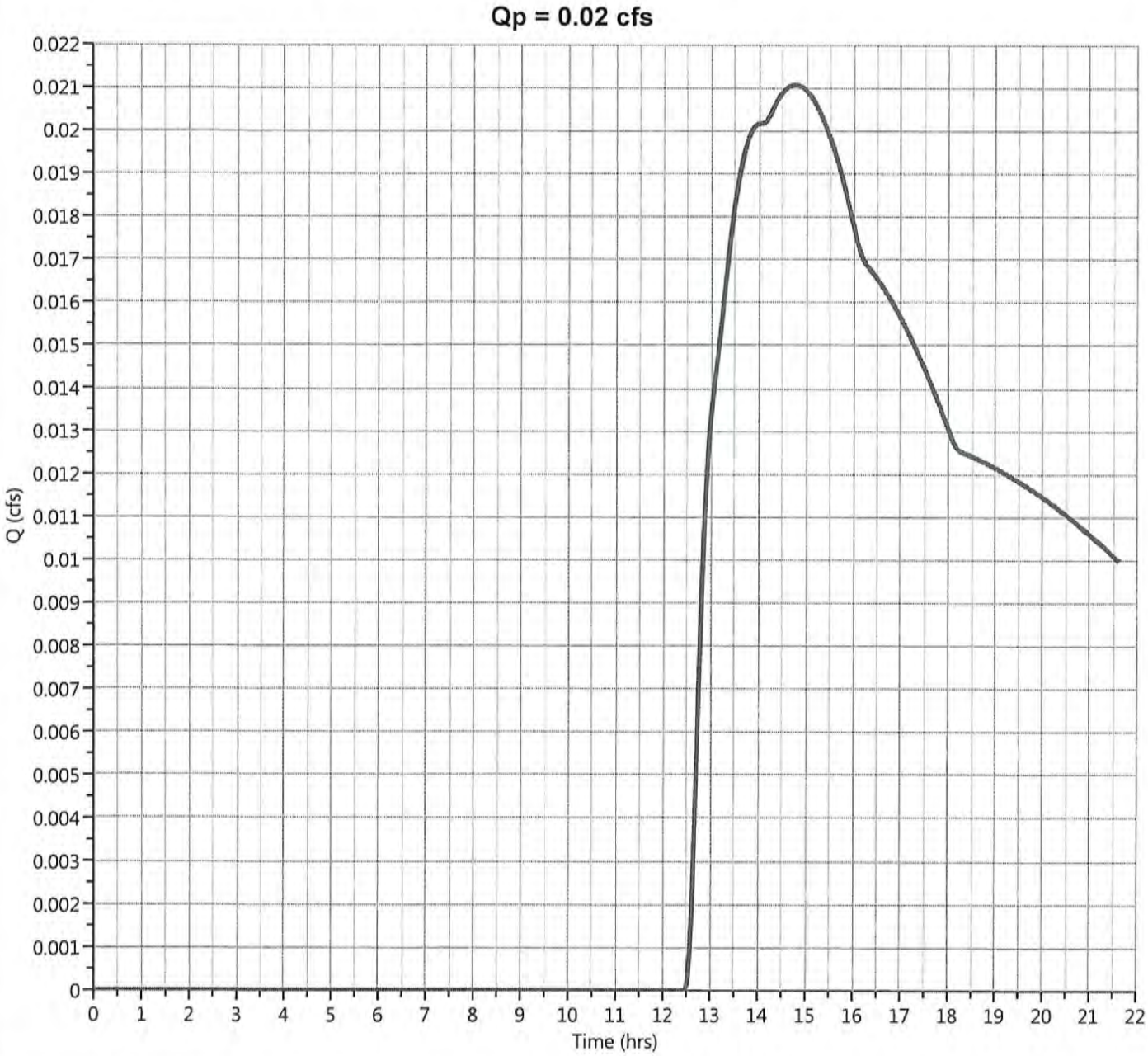
Hydrology Studio v 1.0.0.0

01-29-2019

P-1

Hyd. No. 3

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.021 cfs
Storm Frequency	= 10-yr	Time to Peak	= 14.77 hrs
Time Interval	= 2 min	Runoff Volume	= 571 cuft
Drainage Area	= 1.38 ac	Curve Number	= 39
Tc Method	= User	Time of Conc. (Tc)	= 12.5 min
Total Rainfall	= 4.5000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Hydrograph Report

Project Name:

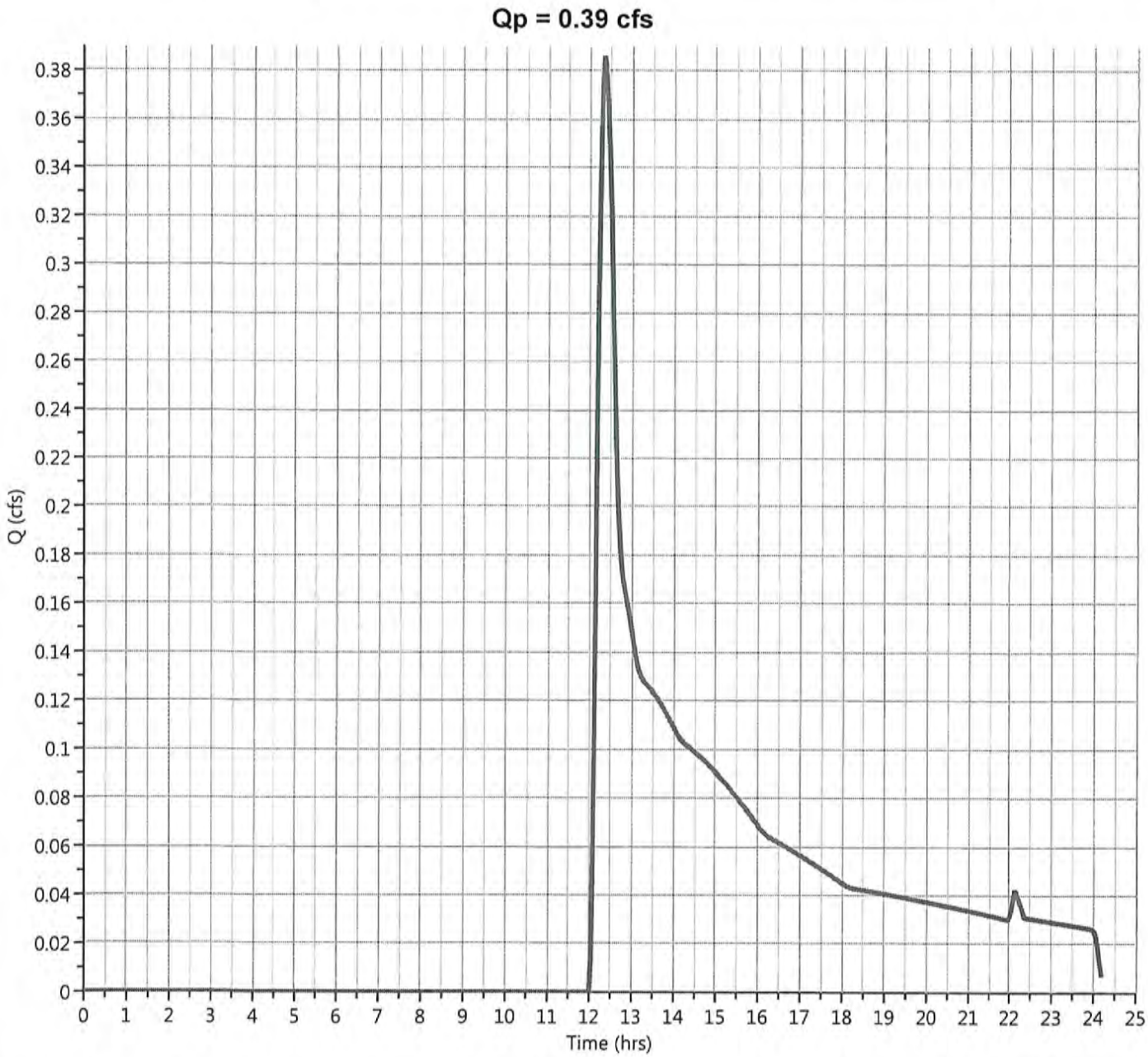
Hydrology Studio v 1.0.0.0

01-29-2019

P-1

Hyd. No. 3

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.386 cfs
Storm Frequency	= 100-yr	Time to Peak	= 12.33 hrs
Time Interval	= 2 min	Runoff Volume	= 3,085 cuft
Drainage Area	= 1.38 ac	Curve Number	= 39
Tc Method	= User	Time of Conc. (Tc)	= 12.5 min
Total Rainfall	= 6.5000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Worksheet 2: Runoff curve number and runoff SM-1323

Project: 493 Massachusetts Avenue By PFK Date 1/28/2019

Location: Boxborough, MA Checked _____ Date _____

Circle one: Present [Developed] P-2

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition: percent impervious: unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area Acres	Product of CN x Area
-	Impervious	98			0.13	12.63
A	Open Space-Good Condition	39			0.05	1.87
A	Woods- Good Condition	30			0.00	0.00
A	Gravel Drive	76			0.00	0.00
C	Open Space-Good Condition	74			0.00	0.00
C	Woods- Good Condition	70			0.00	0.00
C	Gravel Drive and Cartpath	89			0.00	0.00
				Totals =	0.18	14.49

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = $\frac{14.49}{0.18}$ = 82.02 ; Use CN = 82.0

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	2	10	100
Rainfall, P (24-hour)	in	3.1	4.5	6.4
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	1.46	2.64	4.36
Runoff, Q	cf	936	1692	2796

D-2 (210-VI-TR-55, Second Ed., June 1986)

Worksheet 3: Time of Concentration (Tc) or travel time (Tt) SM-1323

Project: 493 Massachusetts Avenue By PFK Date 1/28/2019

Location: Boxborough, MA Checked _____ Date _____

Circle one: Present | Developed

Circle one: Tc | Tt through subarea P-2

Sheet flow (Applicable to Tc only)		Segment ID	A-B			
1. Surface Description (table 3-1)			Paved			
2. Mannings roughness coeff., n (table 3-1)			0.013			
3. Flow length, L (total L <= 300 ft)		ft	50			
4. Two-yr 24-hr rainfall, P2		in	3.1			
5. Land Slope, s		ft/ft	0.02			
6. Tt = 0.007 (nL)^0.8 / (P2^0.5 s^0.4)	Compute Tt	hr	0.01			0.01

Shallow concentrated Flow		Segment ID	B-C	C-D		
7. Surface Description (paved or unpaved)			PAVED	UNPAVED		
8. Flow Length, L		ft	22	64		
9. Watercourse slope, s		ft/ft	0.02	0.025		
10. Average Velocity, V (figure 3-1)		ft/s	2.87	2.55		
11. Tt = L / 3600V	Compute Tt	hr	0.00	0.01		0.01

Channel flow		Segment ID				
12. Cross sectional flow area, a		sf				
13. Wetted perimeter, pw		ft				
14. Hydraulic radius, r=a/wp	Compute r	ft				
15. Channel Slope, s		ft/ft				
16. Manning's roughness coeff., n						
17. V = 1.49 r^2/3 s^1/2 / n	Compute V	ft/s				
18. Flow length, L		ft				
19. Tt = L / 3600V	Compute Tt	hr				0.00

20. Watershed or subarea Tc or Tt (add Tt in steps 6, 11, and 19) hr 0.10

min 6.0

(210-VI-TR-55, Second Ed., June 1986)

Hydrograph Report

Project Name:

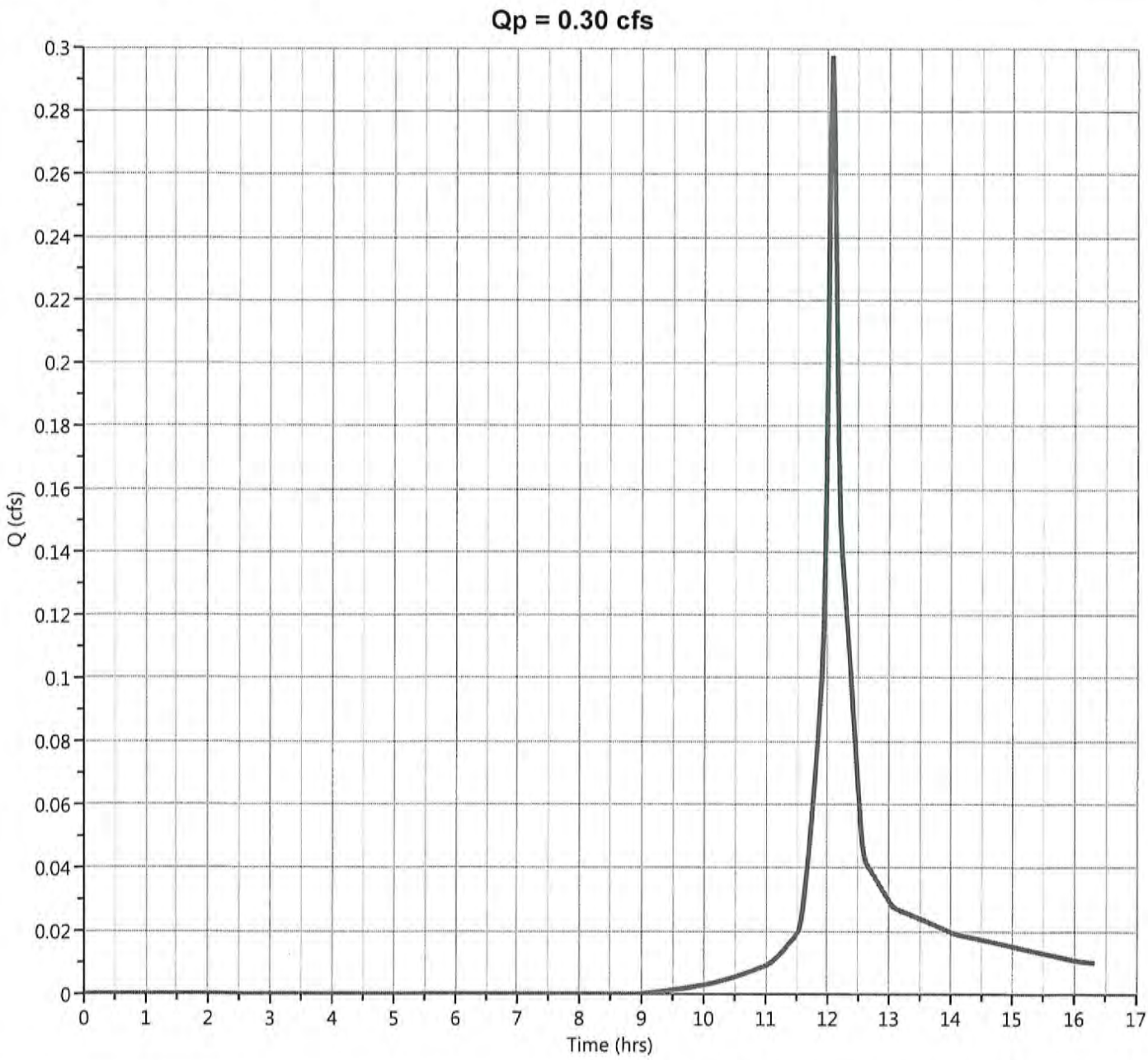
Hydrology Studio v 1.0.0.0

01-29-2019

P-2

Hyd. No. 4

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.298 cfs
Storm Frequency	= 2-yr	Time to Peak	= 12.07 hrs
Time Interval	= 2 min	Runoff Volume	= 893 cuft
Drainage Area	= 0.18 ac	Curve Number	= 82
Tc Method	= User	Time of Conc. (Tc)	= 6.0 min
Total Rainfall	= 3.1000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Hydrograph Report

Project Name:

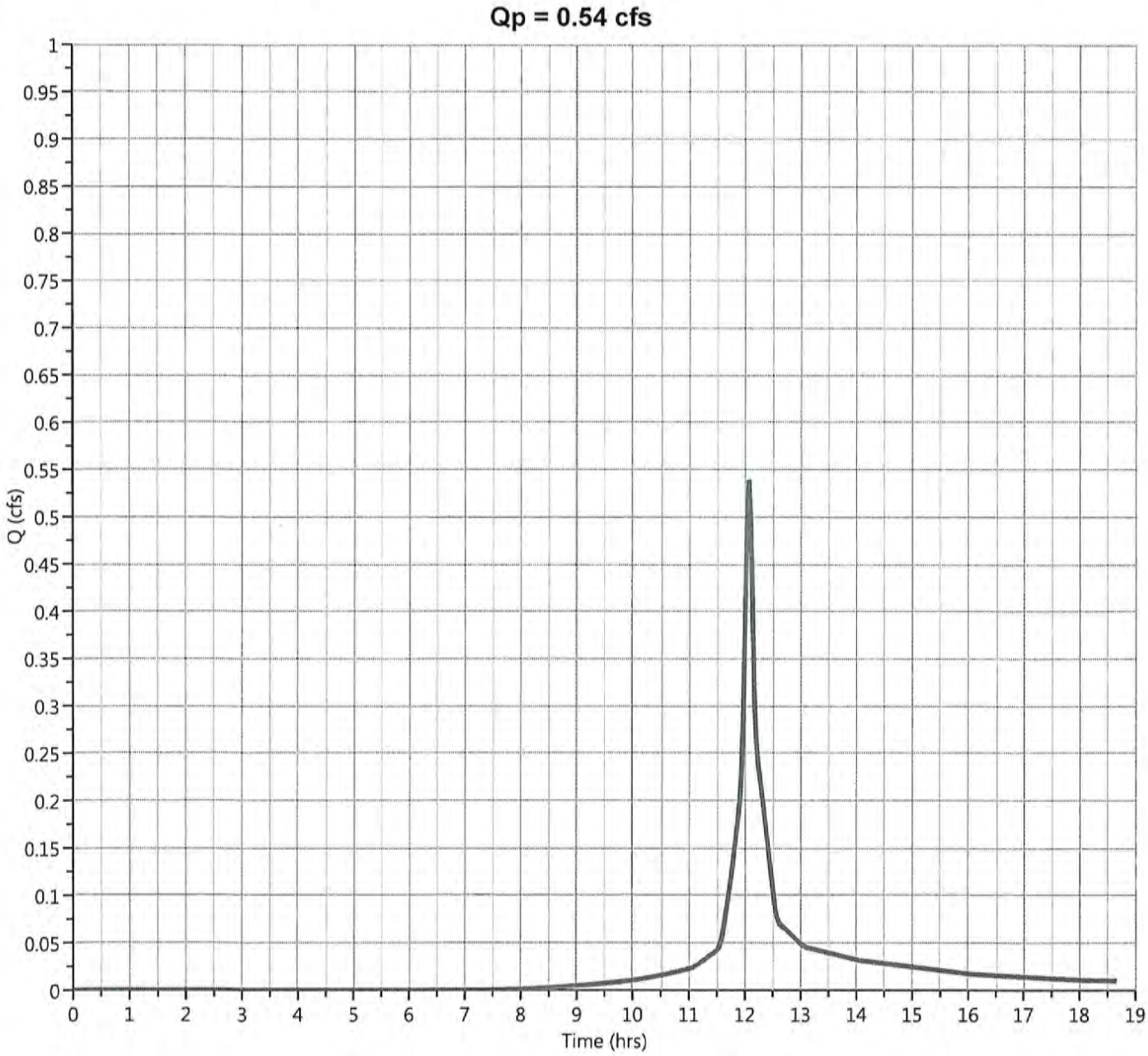
Hydrology Studio v 1.0.0.0

01-29-2019

P-2

Hyd. No. 4

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.540 cfs
Storm Frequency	= 10-yr	Time to Peak	= 12.07 hrs
Time Interval	= 2 min	Runoff Volume	= 1,615 cuft
Drainage Area	= 0.18 ac	Curve Number	= 82
Tc Method	= User	Time of Conc. (Tc)	= 6.0 min
Total Rainfall	= 4.5000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Hydrograph Report

Project Name:

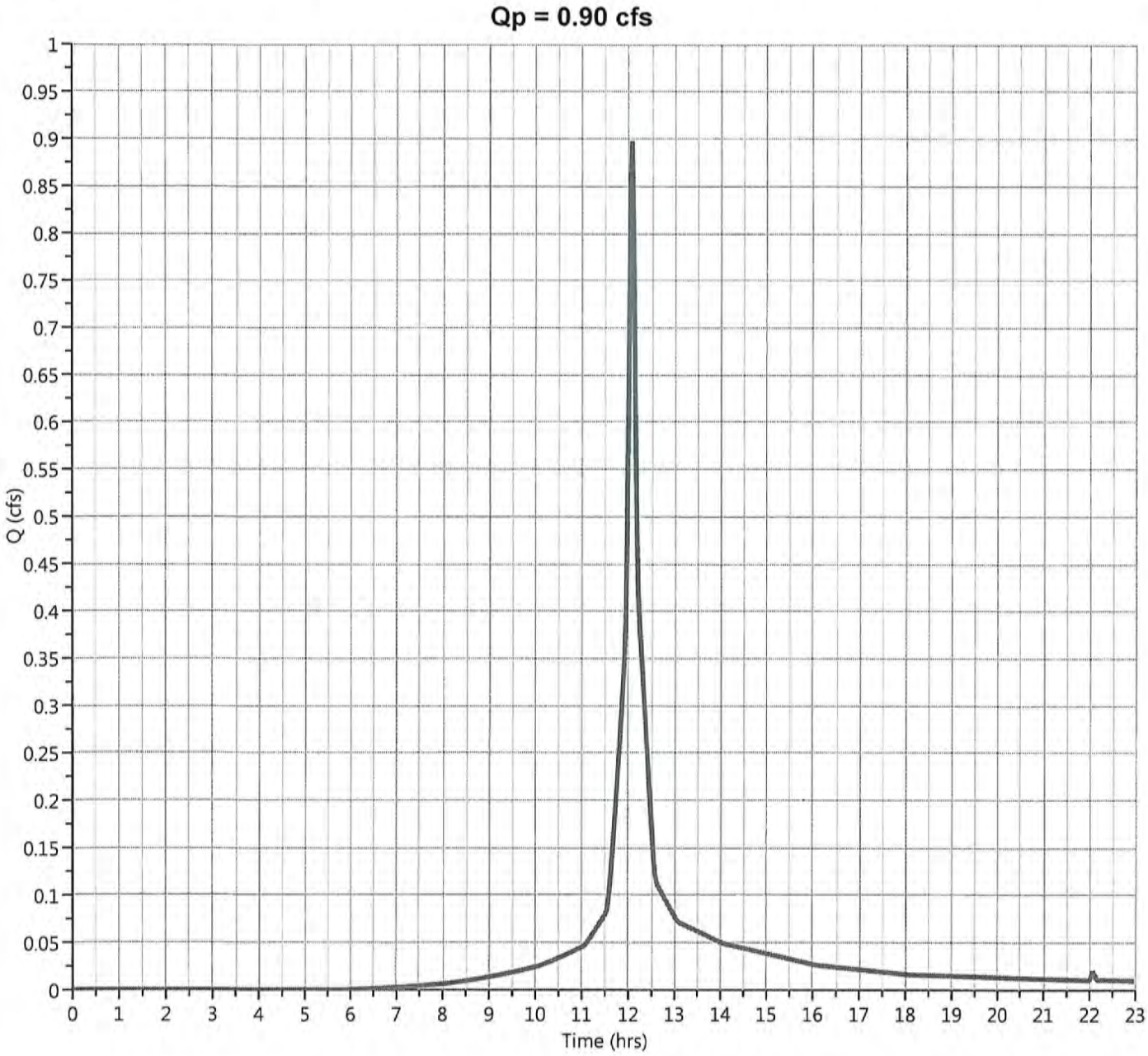
Hydrology Studio v 1.0.0.0

01-29-2019

P-2

Hyd. No. 4

Hydrograph Type	= NRCS Runoff	Peak Flow	= 0.898 cfs
Storm Frequency	= 100-yr	Time to Peak	= 12.07 hrs
Time Interval	= 2 min	Runoff Volume	= 2,726 cuft
Drainage Area	= 0.18 ac	Curve Number	= 82
Tc Method	= User	Time of Conc. (Tc)	= 6.0 min
Total Rainfall	= 6.5000 in	Design Storm	= Type III
Storm Duration	= 24 hrs	Shape Factor	= 484



Hydrograph Report

Project Name:

Hydrology Studio v 1.0.0.0

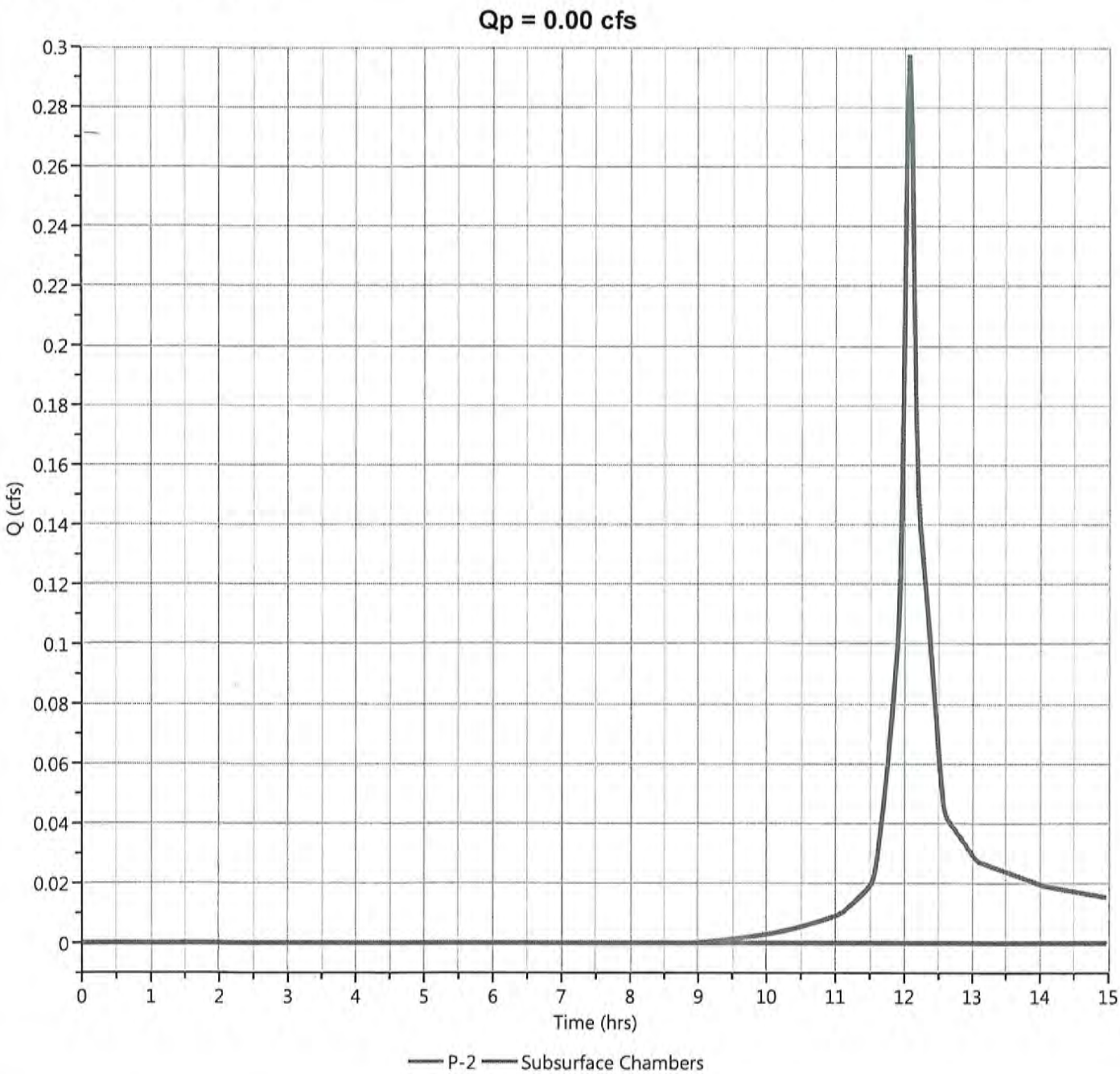
01-29-2019

Subsurface Chambers

Hyd. No. 5

Hydrograph Type	= Pond Route	Peak Flow	= 0.000 cfs
Storm Frequency	= 2-yr	Time to Peak	= 14.93 hrs
Time Interval	= 2 min	Hydrograph Volume	= 0.000 cuft
Inflow Hydrograph	= 4 - P-2	Max. Elevation	= 240.98 ft
Pond Name	= Subsurface Chambers	Max. Storage	= 196 cuft

Pond Routing by Storage Indication Method



Hydrograph Report

Project Name:

Hydrology Studio v 1.0.0.0

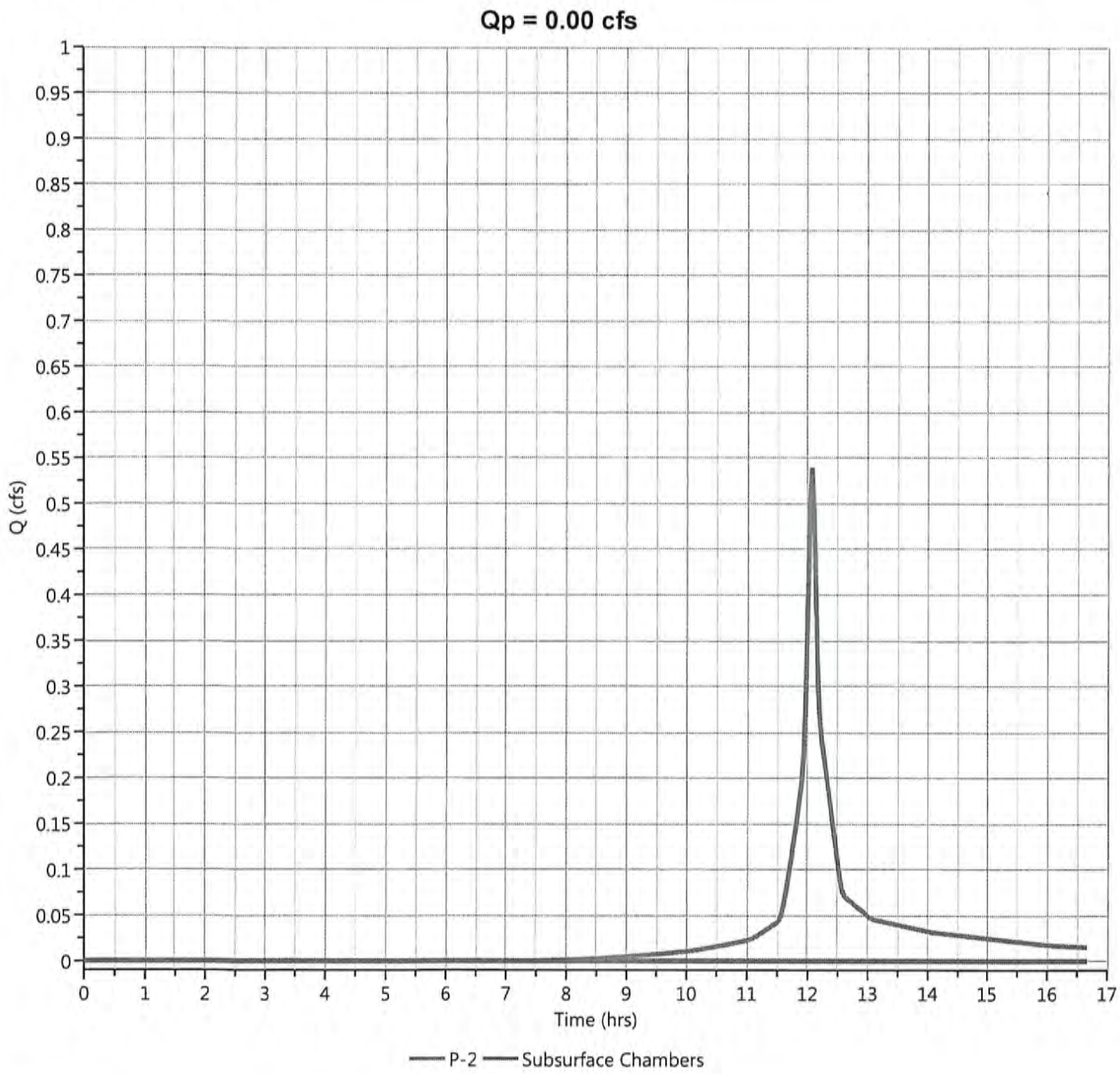
01-29-2019

Subsurface Chambers

Hyd. No. 5

Hydrograph Type	= Pond Route	Peak Flow	= 0.000 cfs
Storm Frequency	= 10-yr	Time to Peak	= 16.63 hrs
Time Interval	= 2 min	Hydrograph Volume	= 0.000 cuft
Inflow Hydrograph	= 4 - P-2	Max. Elevation	= 241.40 ft
Pond Name	= Subsurface Chambers	Max. Storage	= 510 cuft

Pond Routing by Storage Indication Method



Hydrograph Report

Project Name:

Hydrology Studio v 1.0.0.0

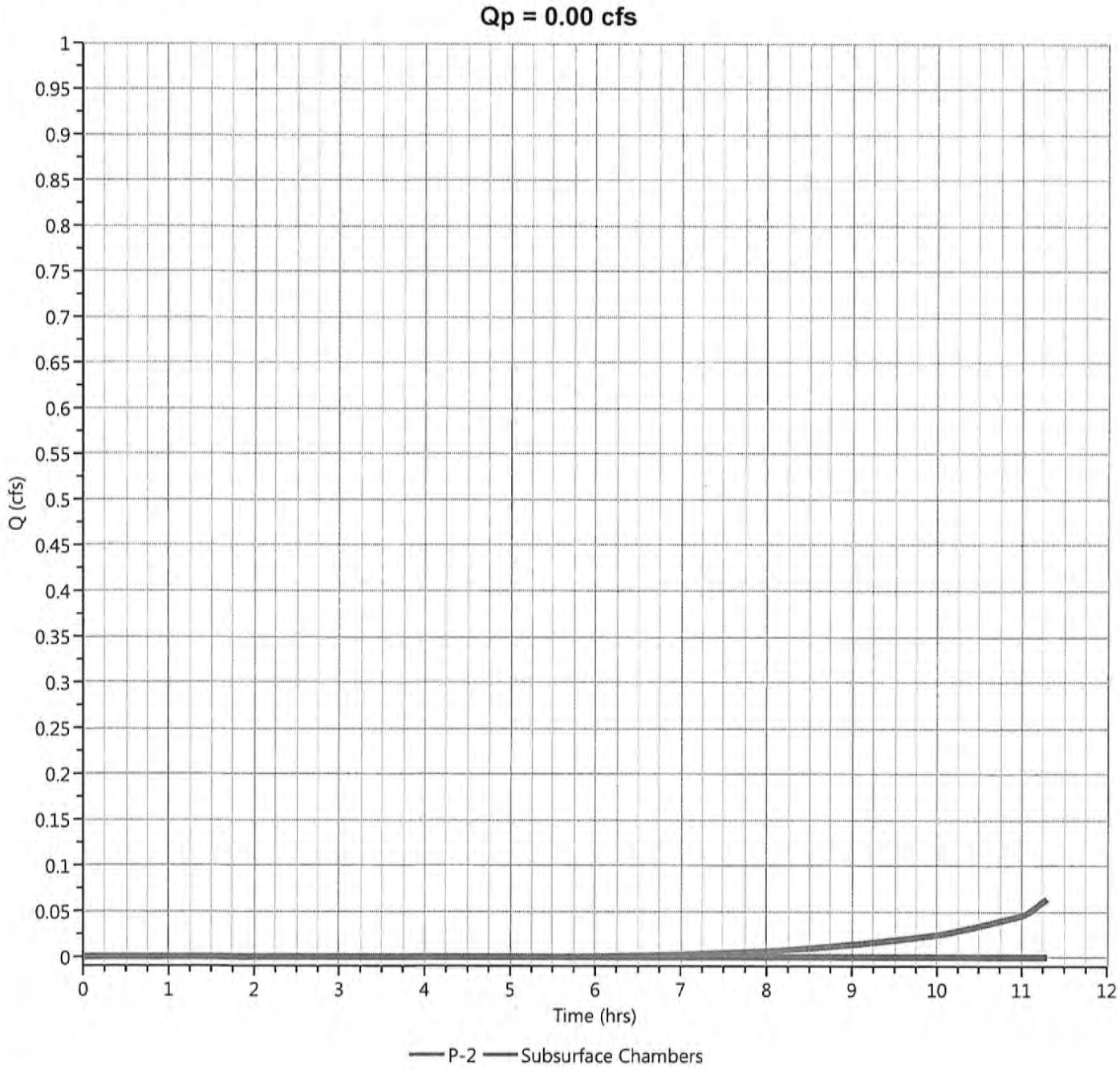
01-29-2019

Subsurface Chambers

Hyd. No. 5

Hydrograph Type	= Pond Route	Peak Flow	= 0.000 cfs
Storm Frequency	= 100-yr	Time to Peak	= 11.27 hrs
Time Interval	= 2 min	Hydrograph Volume	= 0.000 cuft
Inflow Hydrograph	= 4 - P-2	Max. Elevation	= 242.29 ft
Pond Name	= Subsurface Chambers	Max. Storage	= 1,037 cuft

Pond Routing by Storage Indication Method



Pond Report

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

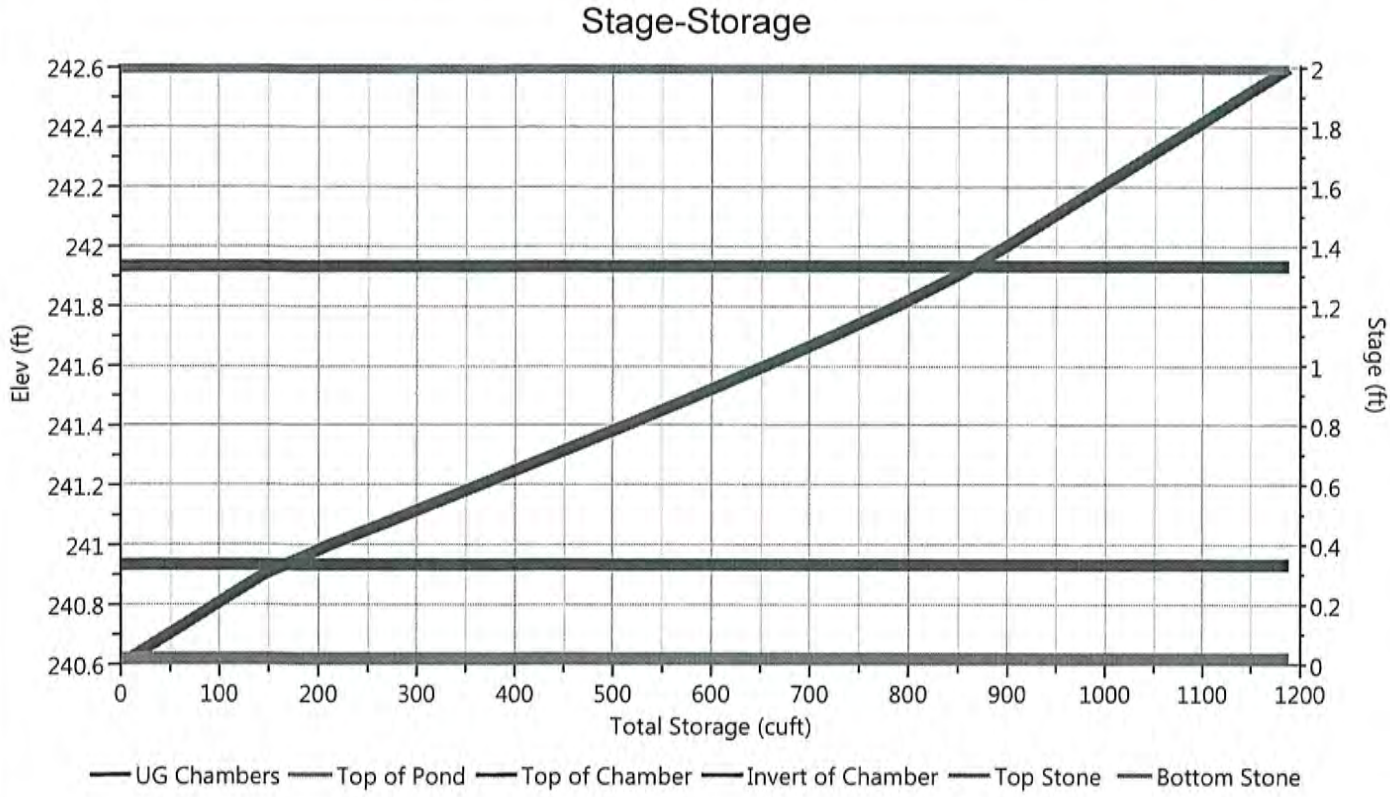
Subsurface Chambers

Description	Input
Chamber Height, in	12
Chamber Shape	Arch
Chamber Width, in	25
Installed Length, ft	7.12
No. Chambers	54
Bare Chamber Stor, cuft	370
No. Rows	6
Space Between Rows, in	6
Stone Above, in	8
Stone Below, in	4
Stone Sides, in	18
Stone Ends, in	18
Encasement Voids, %	40.00
Encasement Bottom Elevation, ft	240.60

Stage-Storage

Stage / Storage Table

Stage (in)	Elevation (ft)	Contour Area (sqft)	Incr. Storage (cuft)	Total Storage (cuft)
0.0	240.60	1,207	0.000	0.000
1.2	240.70	1,207	48.3	48.3
2.4	240.80	1,207	48.3	96.6
3.6	240.90	1,207	48.3	145
4.8	241.00	1,207	66.8	212
6.0	241.10	1,207	76.3	288
7.2	241.20	1,207	75.8	364
8.4	241.30	1,207	75.1	439
9.6	241.40	1,207	73.9	513
10.8	241.50	1,207	72.4	585
12.0	241.60	1,207	70.5	656
13.2	241.70	1,207	67.9	724
14.4	241.80	1,207	64.5	788
15.6	241.90	1,207	59.4	848
16.8	242.00	1,207	50.5	898
18.0	242.10	1,207	48.3	946
19.2	242.20	1,207	48.3	995
20.4	242.30	1,207	48.3	1,043
21.6	242.40	1,207	48.3	1,091
22.8	242.50	1,207	48.3	1,140
24.0	242.60	1,207	48.3	1,188



Pond Report

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Subsurface Chambers

Stage-Discharge

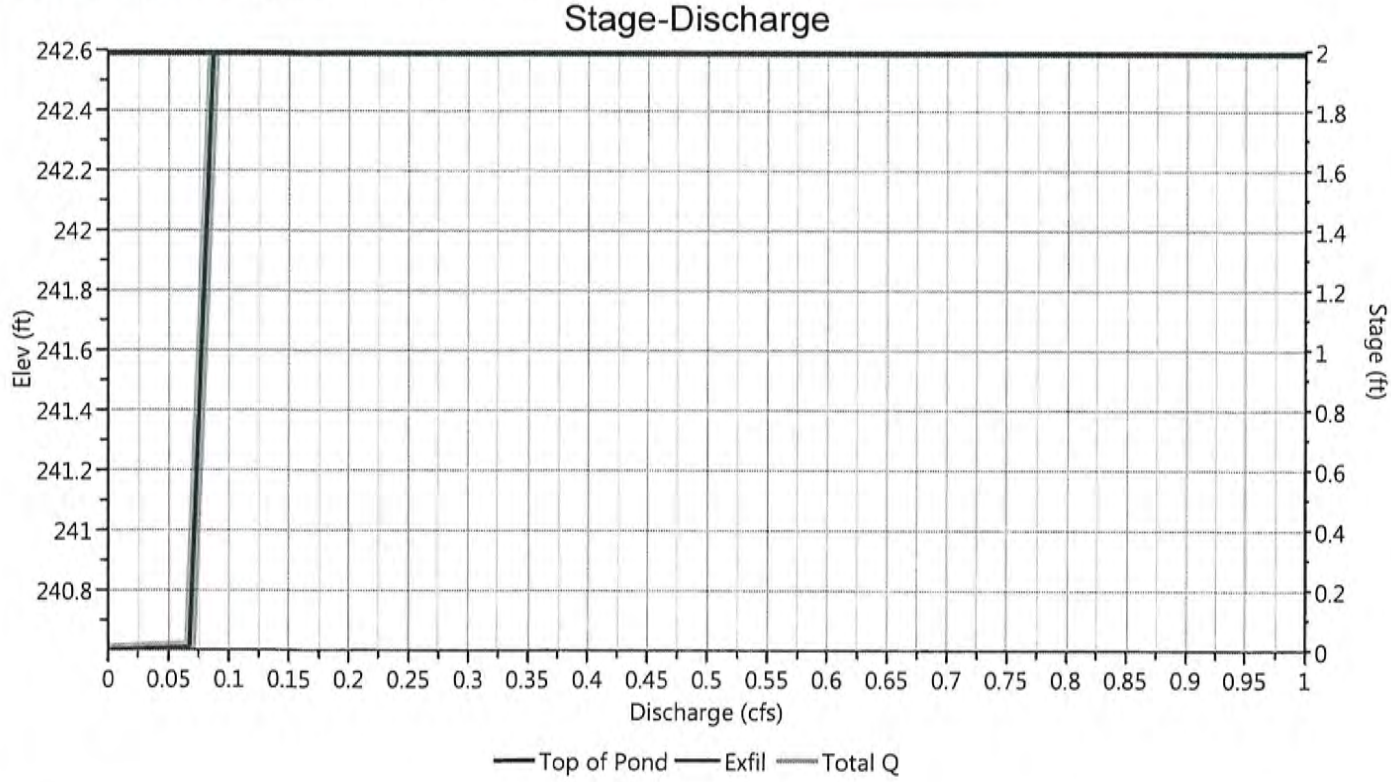
Culvert / Orifices	Culvert	Orifices 1	Orifices 2	Orifices 3
Rise, in				
Span, in				
No. Barrels				
Invert Elevation, ft				
Orifice Coefficient, Co				
Length, ft				
Barrel Slope, %				
N-Value, n	0.000			

Perforated Riser	
Perf. Rise, in	
Perf. Span, in	
No. Perforations	
Invert Elevation, ft	
Height, ft	
Orifice Coefficient, Co	

Weirs	Riser*	Weirs 1	Weirs 2	Weirs 3
Shape / Type				
Crest Elevation, ft				
Crest Length, ft				
Angle, deg				
Weir Coefficient, Cw				

Ancillary	
Exfiltration, in/hr	2.41**

*Routes through Culvert. **Exfiltration extracted from outflow hydrograph. Rate applied to contours.



Pond Report

Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Subsurface Chambers

Stage-Storage-Discharge Summary

Stage (ft)	Elev. (ft)	Storage (cuft)	Culvert (cfs)	Orifices, cfs			Riser (cfs)	Weirs, cfs			Pf Riser (cfs)	Exfil (cfs)	User (cfs)	Total (cfs)
				1	2	3		1	2	3				
0.00	240.60	0.000										0.00		0.00
0.10	240.70	48.3										0.068		0.068
0.20	240.80	96.6										0.069		0.069
0.30	240.90	145										0.070		0.070
0.40	241.00	212										0.071		0.071
0.50	241.10	288										0.072		0.072
0.60	241.20	364										0.073		0.073
0.70	241.30	439										0.074		0.074
0.80	241.40	513										0.075		0.075
0.90	241.50	585										0.076		0.076
1.00	241.60	656										0.077		0.077
1.10	241.70	724										0.078		0.078
1.20	241.80	788										0.079		0.079
1.30	241.90	848										0.080		0.080
1.40	242.00	898										0.081		0.081
1.50	242.10	946										0.082		0.082
1.60	242.20	995										0.083		0.083
1.70	242.30	1,043										0.084		0.084
1.80	242.40	1,091										0.085		0.085
1.90	242.50	1,140										0.086		0.086
2.00	242.60	1,188										0.087		0.087

Suffix key: ic = inlet control, oc = outlet control, s = submerged weir

Pond Report

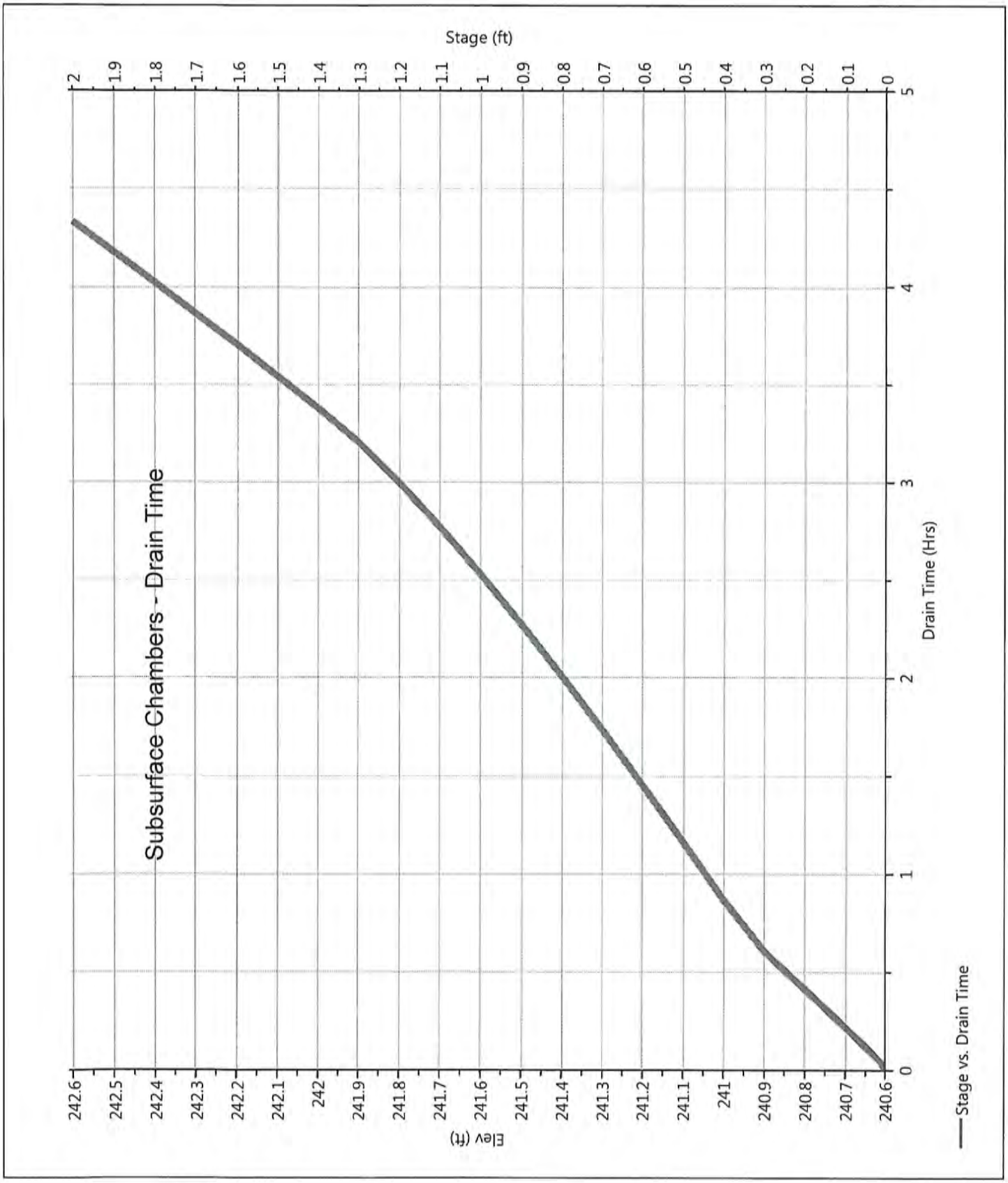
Project Name:

Hydrology Studio v 1.0.0.0

01-29-2019

Subsurface Chambers

Pond Drawdown



Hydrograph Report

Project Name:

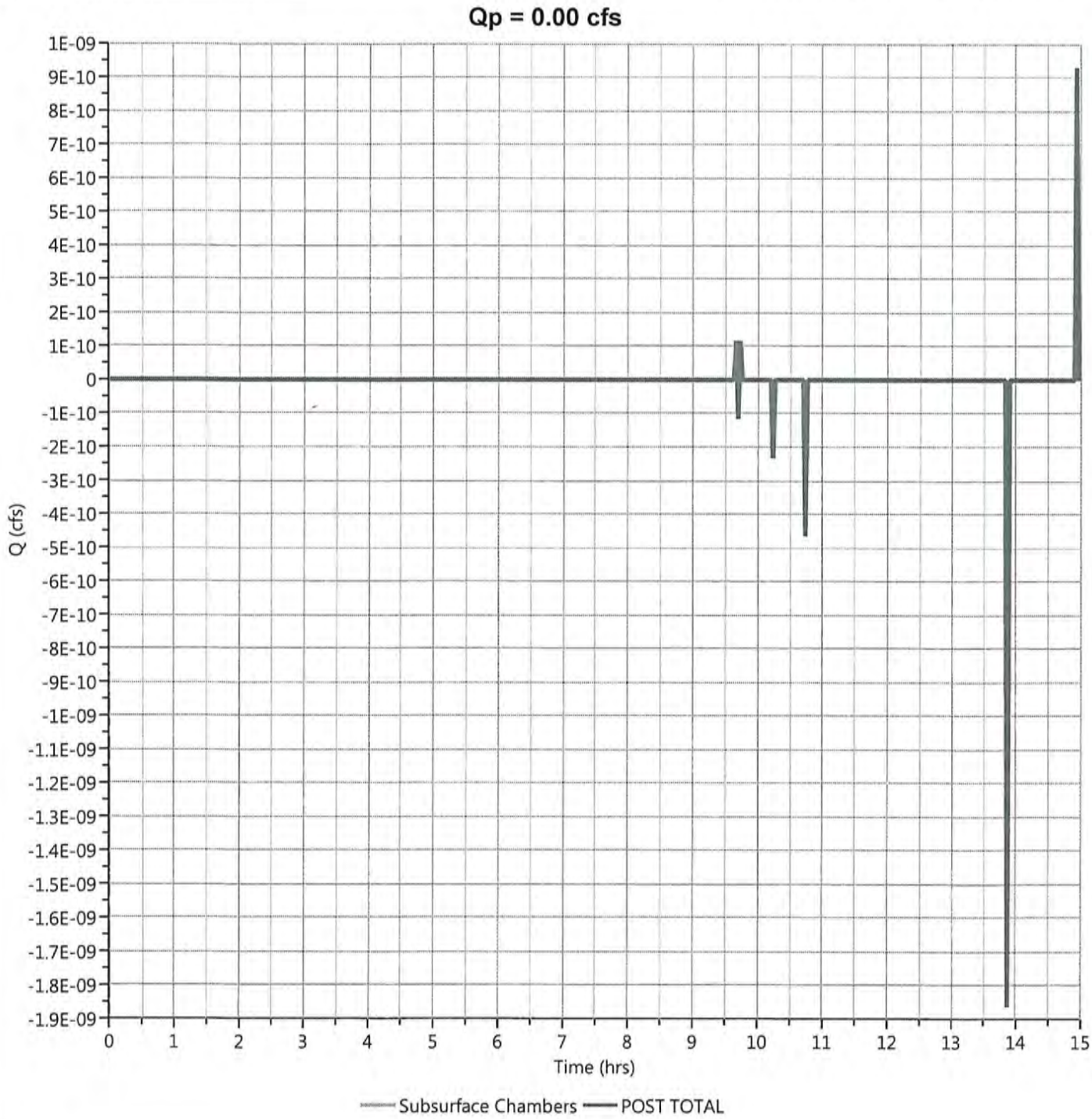
Hydrology Studio v 1.0.0.0

01-29-2019

POST TOTAL

Hyd. No. 6

Hydrograph Type	= Junction	Peak Flow	= 0.000 cfs
Storm Frequency	= 2-yr	Time to Peak	= 14.93 hrs
Time Interval	= 2 min	Hydrograph Volume	= 0.000 cuft
Inflow Hydrographs	= 3, 5	Total Contrib. Area	= 1.38 ac



Hydrograph Report

Project Name:

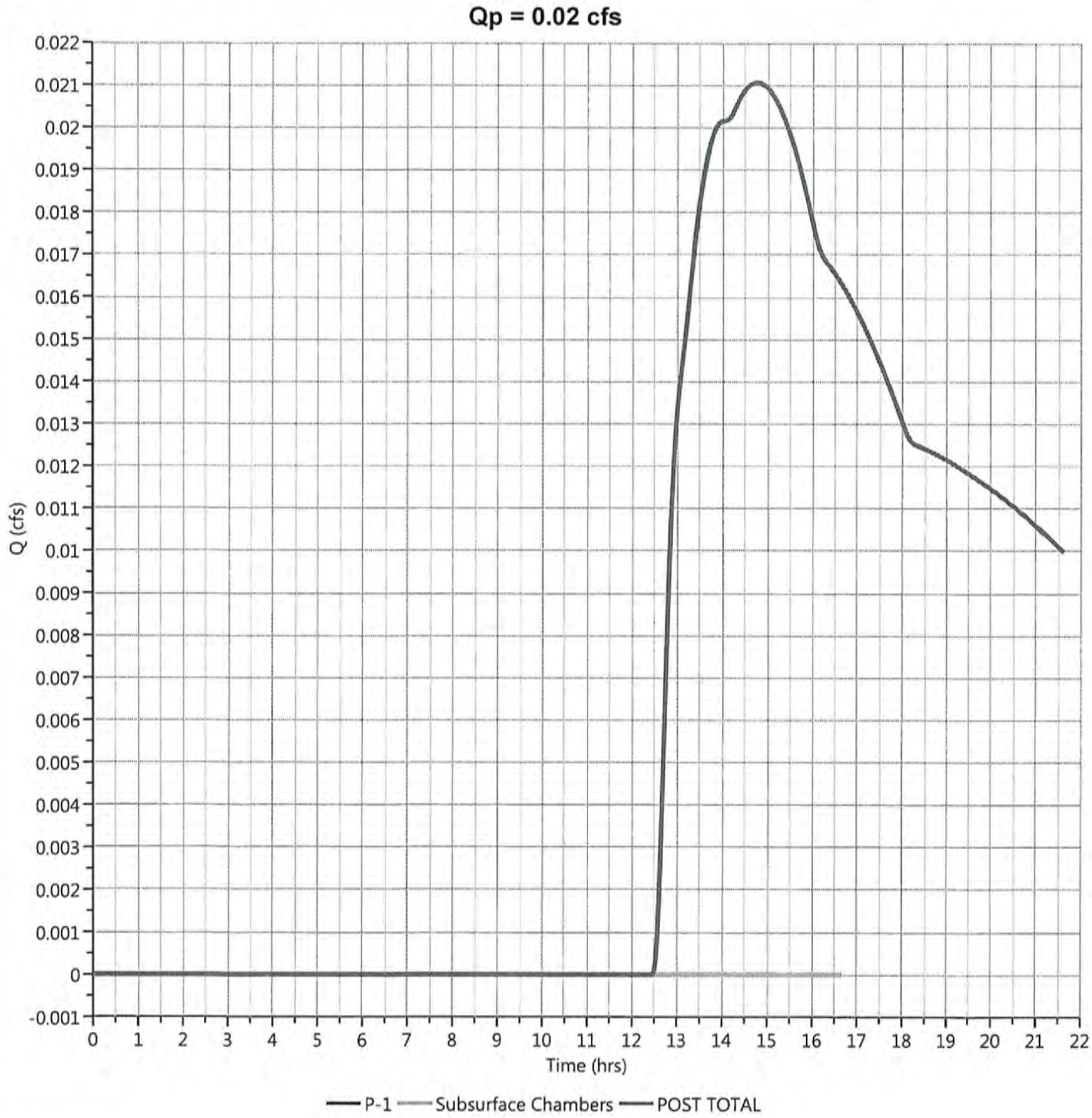
Hydrology Studio v 1.0.0.0

01-29-2019

POST TOTAL

Hyd. No. 6

Hydrograph Type	= Junction	Peak Flow	= 0.021 cfs
Storm Frequency	= 10-yr	Time to Peak	= 14.77 hrs
Time Interval	= 2 min	Hydrograph Volume	= 571 cuft
Inflow Hydrographs	= 3, 5	Total Contrib. Area	= 1.38 ac



Hydrograph Report

Project Name:

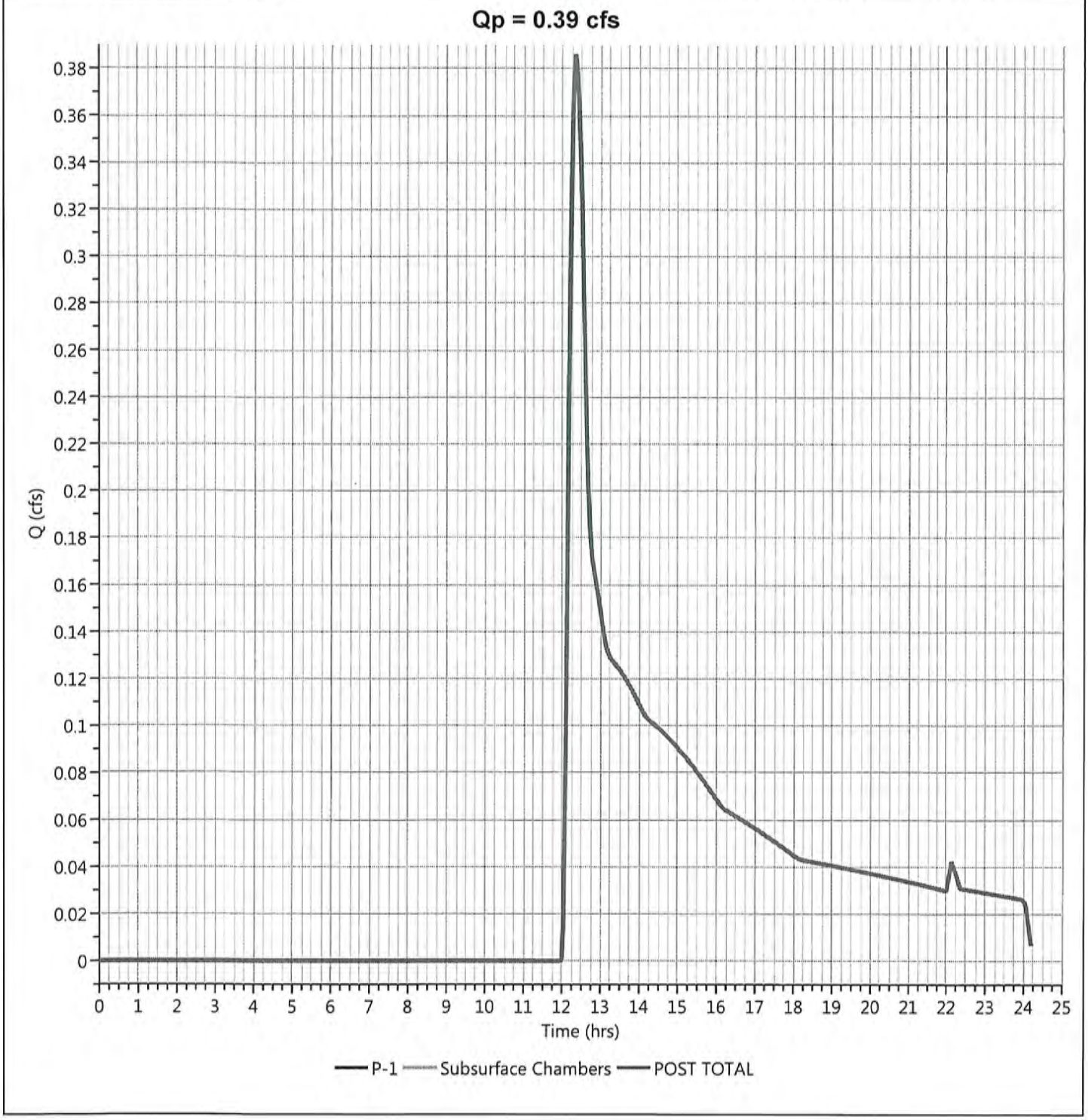
Hydrology Studio v 1.0.0.0

01-29-2019

POST TOTAL

Hyd. No. 6

Hydrograph Type	= Junction	Peak Flow	= 0.386 cfs
Storm Frequency	= 100-yr	Time to Peak	= 12.33 hrs
Time Interval	= 2 min	Hydrograph Volume	= 3,085 cuft
Inflow Hydrographs	= 3, 5	Total Contrib. Area	= 1.38 ac



Water Quality Volume Calculations

Water Quality Volume Calculations

Job: SM-1323

Calculated by: PFK
Date: 1/17/2019

Subcatchment P-2
Soils: Hinckley Loamy Sand
Hydrologic Group: A
Required Water Quality Volume
1 inches of runoff x impervious area

Impervious area: 0.13 acres
5,612 s.f.

Required Water Quality Volume

V= 5,612 s.f. x $\frac{1}{12}$ = 468 c.f.

Volume Provided 1,450 c.f.

1,450	c.f. >	468	c.f. O.K.

TSS Removal Calculations

Project: 493 Massachusetts Ave
Location: Boxborough, MA
Prepared For: Stamski and McNary, Inc.

CONTECH ENGINEERED SOLUTIONS

Purpose: To calculate the water quality flow rate (WQF) over a given site area. In this situation the WQF is derived from the first 1" of runoff from the contributing impervious surface.

Reference: Massachusetts Dept. of Environmental Protection Wetlands Program / United States Department of Agriculture Natural Resources Conservation Service TR-55 Manual

Procedure: Determine unit peak discharge using Figure 1 or 2. Figure 2 is in tabular form so is preferred. Using the tc, read the unit peak discharge (qu) from Figure 1 or Table in Figure 2. qu is expressed in the following units: cfs/mi^2/watershed inches (csm/in).

Compute Q Rate using the following equation:

$$Q = (qu)\ (A)\ (WQV)$$

where:

Q = flow rate associated with first 1" of runoff
qu = the unit peak discharge, in csm/in.
A = impervious surface drainage area (in square miles)
WQV = water quality volume in watershed inches (1" in this case)

Structure Name	Impv. (acres)	A (miles^2)	t_c (min)	t_c (hr)	WQV (in)	qu (csm/in.)	Q (cfs)
WQ	0.50	0.0007813	5.0	0.083	1.00	795.00	0.62

CONTECH ENGINEERED SOLUTIONS

CDS TECHNOLOGIES

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

493 MASSACHUSETTS AVE
BOXBOROUGH, MA

Area	0.50 ac	Unit Site Designation	WQ
Weighted C	0.9	Rainfall Station #	69
t_c	5 min		
CDS Model	1515-3	CDS Treatment Capacity	**1.0 cfs**

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.02	10.2%	10.2%	0.01	0.01	9.8
0.04	9.6%	19.8%	0.02	0.02	9.3
0.06	9.4%	29.3%	0.03	0.03	9.0
0.08	7.7%	37.0%	0.04	0.04	7.3
0.10	8.6%	45.6%	0.05	0.05	8.1
0.12	6.3%	51.9%	0.05	0.05	5.9
0.14	4.7%	56.5%	0.06	0.06	4.3
0.16	4.6%	61.2%	0.07	0.07	4.3
0.18	3.5%	64.7%	0.08	0.08	3.2
0.20	4.3%	69.1%	0.09	0.09	4.0
0.25	8.0%	77.1%	0.11	0.11	7.2
0.30	5.6%	82.7%	0.14	0.14	4.9
0.35	4.4%	87.0%	0.16	0.16	3.8
0.40	2.5%	89.5%	0.18	0.18	2.2
0.45	2.5%	92.1%	0.20	0.20	2.1
0.50	1.4%	93.5%	0.23	0.23	1.1
0.75	5.0%	98.5%	0.34	0.34	3.7
1.00	1.0%	99.5%	0.45	0.45	0.7
1.50	0.0%	99.5%	0.68	0.68	0.0
2.00	0.0%	99.5%	0.90	0.90	0.0
3.00	0.5%	100.0%	1.35	1.00	0.1
					91.0
				Removal Efficiency Adjustment[2] =	6.5%
				Predicted % Annual Rainfall Treated =	93.4%
				Predicted Net Annual Load Removal Efficiency =	**84.5%**

1 - Based on 10 years of hourly precipitation data from NCDC Station 770, Boston WSFO AP, Suffolk County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

Location: Subsurface Chambers Pretreatment

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Grass and Gravel Combination	25%	1.00	0.25	0.75
Deep sump Hooded Area Drain	25%	0.75	0.19	0.56

Total TSS Removal = 44%

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

Project: 6207
Prepared By: PFK
Date: 1/23/2019

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

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

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

Location: Subsurface Chambers

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Grass and Gravel Combination	25%	1.00	0.25	0.75
Subsurface Chambers with Pretreatment	80%	0.75	0.60	0.15

Total TSS Removal = 85%

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

Project: 6207
Prepared By: PFK
Date: 1/23/2019

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

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

Groundwater Recharge Calculations

Recharge Volume Calculations

Job: SM-1323

Calculated by: PFK
Date: 1/23/2019

Infiltration Chambers

Soils: Hinckley Loamy Sand
Hydrologic Group: A
Required Recharge Volume
0.6 inches of runoff x impervious area

Impervious area: 0.13 acres
5,612 s.f.

Required Recharge Volume (Rv)

$$Rv = 5{,}612 \text{ s.f.} \times \frac{0.6}{12} = \mathbf{281 \text{ c.f.}}$$

Simple Dynamic Method
A=Rv / (D*Voids+KT)
Rv=A(D*Voids+kT)

D (depth of infiltration facility):	2	ft
K (saturated hydraulic conductivity):	2.41	inches/hour (confirmed with onsite soil evaluations)
	0.201	feet/hour
T (time):	2	hours
Min. Area=	234	s.f.
Area Provided=	1,207	s.f. ok
Voids=	0.40	(Subsurface Infiltration Chambers)
Rv	1,450	c.f. > 281 c.f.

72 Hour Drawdown
Rv/(K x Bottom Area)= 1.16 Hours
1.16 < 72 hours O.K.

Required Recharge Volume

Job: SM-1323

Calculated by: PFK
Date: 1/23/2019

Required Recharge Volume

Soils: Hinckley Loamy Sand
Hydrologic Group: A
Required Recharge Volume
0.6 inches of runoff x impervious area

Total Impervious Area: 0.17 acres
7,256 s.f.

1.) Required Recharge Volume (Rv)

Rv = 7,256 s.f. x $\frac{0.6}{12}$ = **363 c.f.**

2.) Impervious Area draining to recharge facilities = **5,612 s.f.**

3.) $\frac{7,256}{5,612}$ = **1.29**

4.) Adjusted Minimum Required Recharge Volume

Rv= 363 s.f. x 1.29 = **469 c.f.**

Recharge Volume Provided

Subsurface Infiltration Chambers = 1,450 c.f.

Total Recharge Volume Provided = **1,450 c.f.**

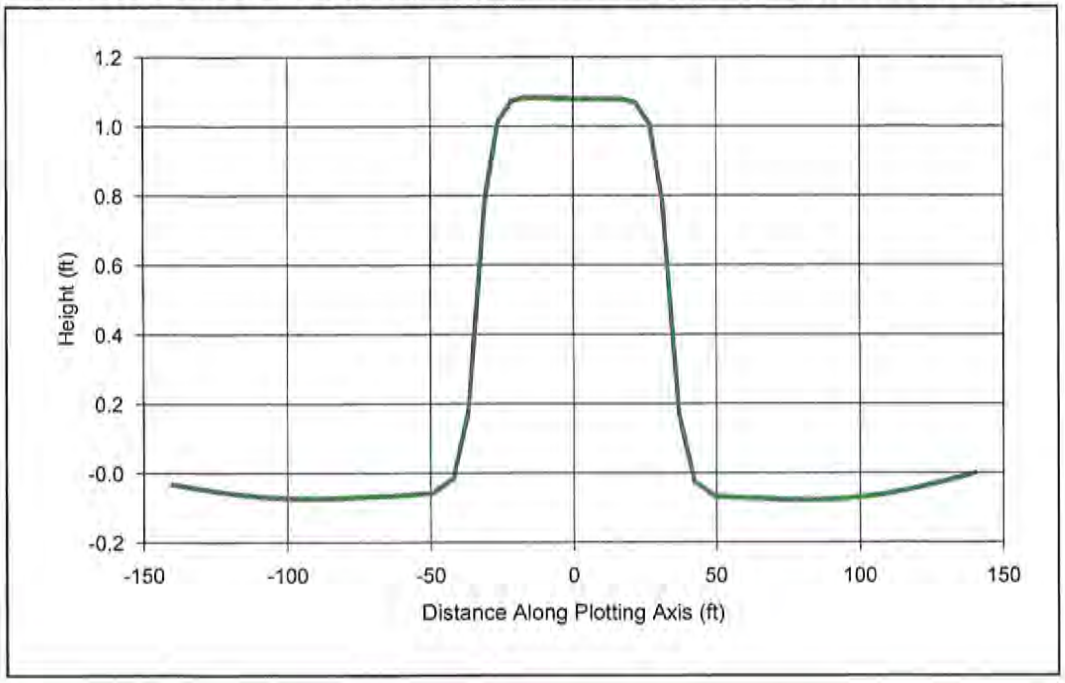
1,450 c.f. ≥ 469 c.f. OK

$\frac{\text{Impervious area being recharged}}{\text{Total Impervious area}} = \frac{5,612}{7,256} = 77\%$

77% ≥ 65% OK

Groundwater Mounding Calculations

Groundwater Mounding Analysis (Hantush's Method using Glover's Solution)



COMPANY: Stamski and McNary, Inc.

PROJECT: Subsurface Chambers

ANALYST: Paul Kirchner

DATE: 1/29/2019 TIME: 2:57:38 PM

INPUT PARAMETERS

Application rate: 0.38 c.ft/day/sq. ft
Duration of application: 1 days
Fillable porosity: 0.31
Hydraulic conductivity: 4.82 ft/day
Initial saturated thickness: 1.42 ft
Length of application area: 67.08 ft
Width of application area: 18 ft
Constant head boundary used at: 140 ft
Plotting axis from Y-Axis: 0 degrees
Edge of recharge area:
positive X: 0 ft
positive Y: 33.5 ft
Total volume applied: 458.8272 c.ft

MODEL RESULTS

X (ft)	Y (ft)	Plot Axis (ft)	Mound Height (ft)
0	-140	-140	-0.03
0	-117.7	-118	-0.06
0	-95.5	-95	-0.07
0	-73.2	-73	-0.07
0	-55.7	-56	-0.06
0	-42.1	-42	-0.02
0	-31.1	-31	0.79
0	-21.7	-22	1.07
0	-13.6	-14	1.08
0	-8.1	-8	1.08
0	-4.4	-4	1.08
0	0	0	1.08
0	4.4	4	1.08
0	8.1	8	1.08
0	13.6	14	1.08
0	21.7	22	1.07
0	31.1	31	0.78
0	42.1	42	-0.02
0	55.7	56	-0.07
0	73.2	73	-0.08
0	95.5	95	-0.07
0	117.7	118	-0.05
0	140	140	0

Pipe Sizing Calculations

DESIGN STORM: 100 YEAR

STORM SEWER DESIGN

DATE: **1/22/2019** REV:

DONE BY: PFK

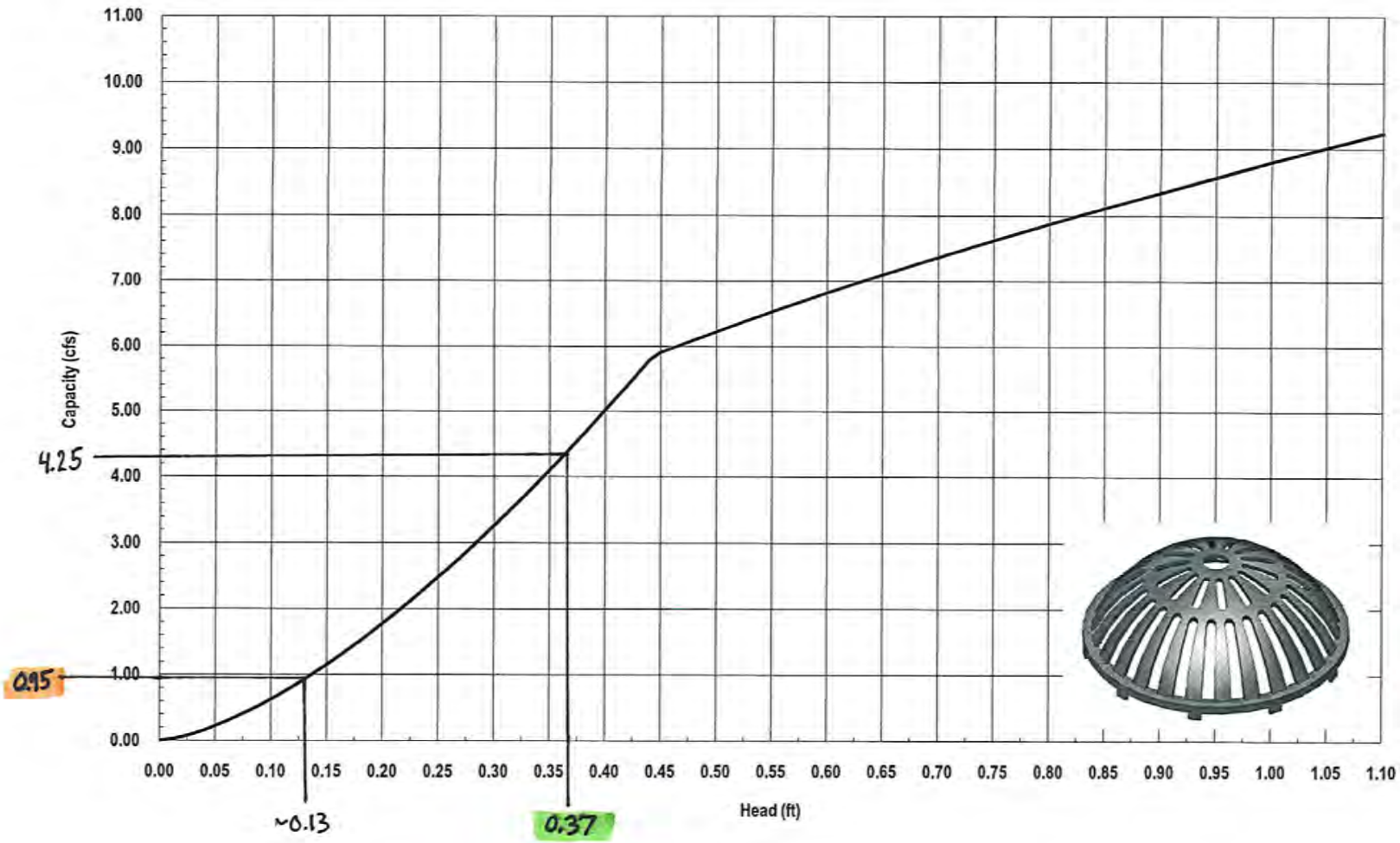
FILE: 1323 RATIONAL METHOD

(ADS N-12)"n"= 0.012 4"-10"
(ADS N-12)"n"= 0.012 12"-36"
(ADS N-12)"n"= 0.012 42"-60"
(Cast Iron)"n"= 0.011

PROJECT: SM-1323
LOCATION: Boxborough, MA

FROM	TO	LENGTH (FT)	TRIBUTARY AREA INCR. (ACRES)	TRIBUTARY AREA TOTAL (ACRES)	TIME OF FLOW TO UPPER END (MIN)	TIME OF FLOW TIME IN SECTION (MIN)	RUNOFF COEFF. "C"	RAINFALL INTENSITY (IN/HR)	"Q" TOTAL RUNOFF (CFS)	SLOPE of PIPE (FT/FT)	DIAM (IN)	MANN. "n"	CAPACITY FULL (CFS)	VELOCITY FULL (FPS)	DESIGN FLOW VELOCITY (FPS)	DESIGN FLOW VELOCITY HEAD (FT)	DESIGN FLOW DEPTH OF FLOW (FT)	DESIGN FLOW TOTAL ENERGY HEAD (FT)	MANHOLE INVERT DROP (FT)	FALL IN PIPE (FT)	DRAIN INV. ELEVATION UPPER END	DRAIN INV. ELEVATION LOWER END	GROUND SURFACE UPPER END	GROUND SURFACE LOWER END
CB-1	Manifold	8	0.17	0.17	10	0.03	0.74	7.6	0.95	0.012	8	0.012	1.46	4.18	4.44	0.31	0.39	0.70		0.10	241.13	241.03	242.38	242.60

Nyloplast 24" Dome Grate Inlet Capacity Chart



Nyloplast®
3130 Verona Avenue • Buford, GA 30518
(866) 888-8479 / (770) 932-2443 • Fax: (770) 932-2490

© Nyloplast Inlet Capacity Charts June 2012

- DESIGN INFLOW RATE
- OVERFLOW BERM ELEVATION

Soil Evaluations

Commonwealth of Massachusetts
City/Town of

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

A. Facility Information

Acton-Boxborough Regional School District
Owner Name

493 Massachusetts Ave
Street Address

15-002-000
Map/Lot #

Boxborough
City

MA
State

01719
Zip Code

B. Site Information

DRAINAGE

1. (Check one) ☐ New Construction ☐ Upgrade ☐ Repair

2. Soil Survey Available? ☒ Yes ☐ No If yes: Web Soil Survey (Source) _____ (Soil Map Unit)

Hinckley Loamy Sand
Soil Name

_____
Soil Limitations

Sandy & Gravelly glacio fluvial deposits
Soil Parent material

outwash terrace, outwash delta, outwash plains, eskers, moraines, kame terrace, kame
Landform

3. Surficial Geological Report Available? ☒ Yes ☐ No If yes: Oliver (Year Published/Source) _____ (Map Unit)

S & G
Description of Geologic Map Unit:

4. Flood Rate Insurance Map Within a regulatory floodway? ☐ Yes ☒ No

5. Within a velocity zone? ☐ Yes ☒ No

6. Within a Mapped Wetland Area? ☐ Yes ☒ No If yes, MassGIS Wetland Data Layer: _____ (Wetland Type)

7. Current Water Resource Conditions (USGS): 1/17/2019 (Month/Day/ Year) Range: ☒ Above Normal ☐ Normal ☐ Below Normal

8. Other references reviewed: _____

Commonwealth of Massachusetts
City/Town of

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

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-1 (Hole #) 1/18/19 (Date) 10:00 AM (Time) 30° cloudy (Weather) ___ (Latitude) ___ (Longitude)

1. Land Use: school (e.g., woodland, agricultural field, vacant lot, etc.) lawn (Vegetation) — (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 0-3 (Slope (%))

Description of Location: edge of parking lot

2. Soil Parent Material: S & G ___ (Landform) TS (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >50 feet; Drainage Way >50 feet; Wetlands >75 feet; Property Line >10 feet; Drinking Water Well >100 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: 64 Depth Weeping from Pit; 70 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			
60	FILL										
72	C	Gravelly loamy Sand	10YR 4/2	60		2	30	20			

Additional Notes:

Commonwealth of Massachusetts
City/Town of

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

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-2 (Hole #) 1/18/19 (Date) 11:00 AM (Time) _____ (Weather) _____ (Latitude) _____ (Longitude:)

1. Land Use: _____ (e.g., woodland, agricultural field, vacant lot, etc.) Vegetation _____ Surface Stones (e.g., cobbles, stones, boulders, etc.) _____ Slope (%) _____

Description of Location: _____

2. Soil Parent Material: _____ Landform _____ Position on Landscape (SU, SH, BS, FS, TS) _____

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Wetlands ____ feet
Property Line ____ 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: 59 Depth Weeping from Pit 61 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			
55	FILL										
72	C	LS	10YR 4/2	55		2	30	20			

Additional Notes: _____

Commonwealth of Massachusetts
City/Town of

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

D. Determination of High Groundwater Elevation

1. Method Used:

	Obs. Hole #_____		Obs. Hole #_____
☐ Depth observed standing water in observation hole	_____ inches		_____ inches
☐ Depth weeping from side of observation hole	_____ inches		_____ inches
☒ Depth to soil redoximorphic features (mottles)	_____ inches	SEE	_____ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	LOGS	_____ inches

_____ Index Well Number _____ Reading Date

$S_h = S_c - [S_r \times (OW_c - OW_{max})/OW_r]$

Obs. Hole/Well# _____ S_c _____ S_r _____ OW_c _____ OW_{max} _____ OW_r _____ S_h _____

2. Estimated Depth to High Groundwater: 55 inches

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system?

☐ Yes ☐ No

b. If yes, at what depth was it observed (exclude A and O Horizons)? Upper boundary: _____ inches Lower boundary: _____ inches

c. If no, at what depth was impervious material observed? Upper boundary: _____ inches Lower boundary: _____ inches

Commonwealth of Massachusetts
City/Town of

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

F. Certification

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

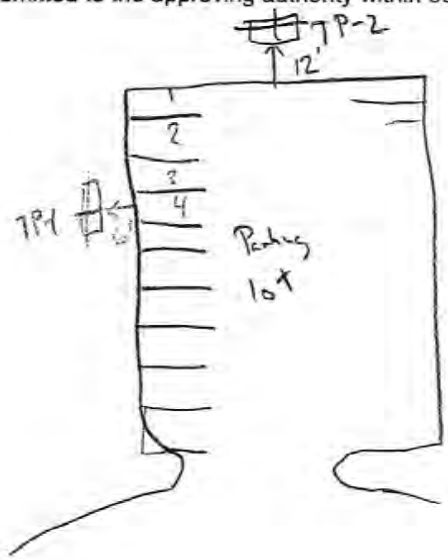
Signature of Soil Evaluator — Date: 1/18/19

Typed or Printed Name of Soil Evaluator / License #: Paul Kirchner SE 14237 — Expiration Date of License: 7/1/2021

Name of Approving Authority Witness — Approving Authority

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Field Diagrams: Use this area for field diagrams:



Drainage Maps

Stormwater Operation and Maintenance Manual

Stormwater Operation and Maintenance Manual

For

493 Massachusetts Avenue
Parcels 15-002-000
Boxborough, MA

January 30, 2019

Stamski And McNary, Inc.
Engineering - Planning – Surveying
1000 Main Street; Acton, MA 01720 (978) 263-8585
www.stamskiandmcnary.com

SM-1323

Table of Contents

Long Term Operation and Maintenance Plan

Operation and Maintenance Sample Inspection Log

Long Term Operation and Maintenance Plan

Schedule for Inspection and Maintenance:

Subsurface Chambers:
Inspect the system after every major storm for the first few months to ensure proper stabilization and function. Thereafter, inspect and clean it at least twice per year. Water levels should be recorded over several days to check the structures drainage. Also, mosquito controls may be necessary.

Street Sweeping:
It is recommended that the pavement shall be properly swept twice a year, with concentrations in the spring and the fall.

Deep Sump and Hooded Catch Basins:
During construction, catch basin grates shall be wrapped with filter fabric. Catch basins shall be cleaned upon the completion of construction. After construction, the deep sumps for all catch basins and drain manholes shall be inspected four times a year and cleaned four times a year. Sediment removed shall be disposed of in accordance with applicable local, state, and federal guidelines and regulations. The depth of the sediment in a basin shall not exceed a depth of 18 inches as determined by probing with a stick. If the stick hits the bottom within 30 inches of the water level, more than 18 inches of sediment has accumulated and must be removed. Licensed persons should remove and dispose of the contents of the sump in accordance with applicable regulations.

CDS 1515-3-C: (DMH-1)
Inspection and maintenance of CDS units can be performed from the surface, without entry into the unit. Perform maintenance a minimum of twice per year. CDS units shall be cleaned once sediment has reached 75% of the storage capacity.
Perform frequent inspections during the first year of installation to accurately establish the maintenance schedule.
Remove oil and sediment through the manhole cover with the use of a vacuum truck. Disposal from the CDS units is similar to that of any other best management practice (BMP). Consult local guidelines or your Contech area marketing manager prior to disposing the separator contents.

Emergency Contacts:
In the event of a hazardous materials spill on the site the following parties shall be contacted:
Boxborough Fire Department: ph: 978-264-1770

Records:
The Responsible Party shall maintain an inspection log of all elements of the storm water management plan. The Responsible Party shall maintain a maintenance log documenting the inspection and maintenance of the drainage structures under his control. A copy of the erosion control and storm water maintenance plan and inspection logs shall be kept onsite at all times.

Budget: The estimated annual operation and maintenance budget is $500.

Responsible Party:
The Applicant shall be responsible for all inspection and maintenance of the items included in the Manual during construction. Subsurface structures and manholes shall be the responsibility of the Applicant.

Name: _____

Signature: _____

Date: _____

Operation and Maintenance Sample Inspection Log

493 Massachusette Avenue

Operation and Maintenance Inspection Log

Year: _____

Inspection Items:	Frequency:
Street Sweeping	**Two times per year**
Catch Basins	**Four times per year**
Subsurface Chambers	**Two times per year**

Street Sweeping:

Previous Inspection Date: _____
Inspection Date: _____
Inspector Name: _____
Comments:

Action Required:

Deep Sump Basin/Contech CDS 1515-3-C

Previous Inspection Date: _____
Inspection Date: _____
Inspector Name: _____
Sediment Depth: _____ (Remove if depth greater than 18")
Comments:

Action Required:

Subsurface Chambers

Previous Inspection Date: _____
Inspection Date: _____
Inspector Name: _____
Comments:

Action Required: