DRAINAGE REPORT

Site Development
The Sanctuary at Manchester by the Sea
Manchester-by-the-Sea, MA

Prepared: 07/16/2021
Revised: 03/23/2022

Site Locus – Not to Scale

CLIENT:
SLV School Street, LLC
257 Hillside Avenue
Needham, MA 02494

PREPARED BY:
Allen & Major Associates, Inc.
100 Commerce Way, Suite 5
Woburn, Massachusetts 01801
EOR: Carlton M. Quinn, PE

allenmajor.com

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ISSUED:
July 16, 2021

REVISED:
March 23, 2022

A&M PROJECT NO.:
2725-01

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SECTION 1.0 - NARRATIVE

INTRODUCTION

The purpose of this drainage report is to provide an overview of the proposed stormwater management system (SMS) for the site facility development proposed at School Street in Manchester-by-the-Sea. The report will show by means of narrative calculations and exhibits that the proposed stormwater management system will meet or exceed the 10 Massachusetts Department of Environmental Protection (MassDEP) stormwater standards.

The proposed site improvements include construction of a 92,560± square foot (s.f.), multi-family residential building with associated surface and garage parking, building utilities, stormwater management system, landscaping, and grading. The project will be serviced by municipal sewer & water, and private electric and gas.

The SMS incorporates structural and non-structural Best Management Practices (BMPs) to provide stormwater peak flow mitigation, quality treatment, and conveyance. The SMS includes catch basins with snouts and hoods, drain manholes, hydrodynamic water quality units, bio-retention/rain gardens, equipped with an overflow outlet control structure/catch basin, and a subsurface infiltration system comprised of 96" corrugated metal pipe (CMP) equipped with an outlet control structure.

SITE CATEGORIZATION FOR STORMWATER REGULATIONS

The proposed site improvements are considered a new development under the DEP Stormwater Management Standards due to the net increase in impervious area.

SITE LOCATION AND ACCESS

The project site consists of one parcel of land located on School Street, identified on the Town of Manchester Assessors Tax Maps as Map 43 Lot 18. The parcel is comprised of a 23.7± acre parcel (Map 43 Lot 18). The site is currently undeveloped with forested uplands and bordering vegetated wetlands.

Manchester is located in Essex County and is approximately 30 miles north-east of Boston. The site is located approximately 25 miles east/south-east of Interstate 495.

EXISTING SITE CONDITIONS

The Project Site is a 23.7± acre parcel (Map 43 Lot 18) that is currently undeveloped and consists of upland wooded areas, a gravel path, and lowland wetland areas. There are several wetland areas surrounding the Site; these areas were delineated by a wetland specialist and are represented by a several series of wetland flags.

The topography of can be described as a wooded hill or mountain, with the peak/top near the center of the property at El. 151.0±. The perimeter of the site to the west, north, and east is roughly El. 48.0±. There an on-site depression southwest of the hill/mountain peak, which is at El. 92.0± that keeps a significant amount of water on site.

There areas with significant ledge/bedrock outcroppings and areas where perc tests and deep hole excavations were performed and found sandy loam. See the Section below entitled "Existing Soil Conditions" for further information regarding soils on site.

WATERSHED

The subject property is located within the North Coastal Watershed. The North Coastal Watershed has a total drainage area of 168 square miles, and encompasses all or part of five river sub-basins. The North Coastal also encompasses all or part of 26 Massachusetts municipalities and supports a population of approximately 500,000 people. Dominant resources within the region include a major lobster fisheries and shell fishing, which remains a major commercial and recreational activity. The North Coastal Watershed is not protected under the Watershed Protection Act and has no associated land use restrictions.

EXISTING SOIL CONDITIONS

The on-site soils were identified using the USDA Natural Resources Conservation Services (NRCS) Soil Survey for Essex County. The site soil types and corresponding Hydrologic Soil Groups (HSG) include:

- 102E – Chatfield-Hollis-Rock outcrop complex, 15 to 35 percent slopes, HSG - D.
- 651 – Udorthents, smoothed, 0 to 3 percent slopes no associated HSG, assumed HSG – D.

Udorthents consists of areas where the soil has been altered or obscured by buildings, or paved areas; neither urban land nor Udorthents are assigned a hydrologic soil group (HSG). Soils on-site have an associated HSG rating of "D" which is reserved for soils with little to no infiltration rate. The existing site shows signs of rock outcrops and exposed ledge, while the surficial geology shows potential drumlins and lodgment till in the area. A copy of the soil mapping from the NRCS website is included in the Appendix of this report.

While the USDA NRCS Soil Survey indicates this area as poorly-drained (HSG-D), field investigation, testing, and observation has provided evidence that areas on-site have much more acceptable material for infiltration.

Miller Engineering provided a Geo-technical report with a grain-size distribution report and accompanying USDA Soil Classification Pyramid. According to the sample taken from the project site, the material is a "loamy sand" or HSG-A class soil (see attachment C in the Geotechnical Report, provided in the appendix).

Twelve (12) deep-hole test pits and five (5) percolation tests were performed by a Massachusetts Soil Evaluator and witnessed by a MassDEP agent. Testing was performed by On-Site Engineering on November 18th and 19th, 2020. A copy of the Form 11 & Form 12 soil test logs can be found in the appendix of this report.

FEMA FLOODPLAIN/ENVIRONMENTAL DUE DILIGENCE

The latest Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) within 25009C432G & 25009C0434G, effective July 16, 2014, was reviewed and it was determined that the 100-year floodplain "Zone A" area is located within the Parcel "L" project site. All proposed work on the site is located within a Zone X (unshaded). Zone "X" (unshaded) areas are areas determined to be out of the 500-year flood zones. See the Existing Conditions Plan prepared by Allen & Major Associates, Inc. and Section 3.0 – Exhibits of this report for a more detailed representation of the FEMA flood zone locations in relation to the site. A Notice of Intent will be filed with the State and the Town.

ENVIRONMENTALLY SENSITIVE ZONES

A review of the latest Massachusetts Natural Heritage Atlas; 14th Edition, reveals that there are no Estimated Habitats nor Priority Habitats located on the subject site. It should be noted that a Priority Habitat is located on the north side of Sawmill Brook and that.

A review of the MassGIS on-line program Mass Mapper (formerly OLIVER) indicates Sawmill Brook, located approximately 100 feet north of the project, is a cold-water fishery and considered an Area of Critical Environmental Concern (ACEC).

A review of the Massachusetts Cultural Resource Information System (MACRIS) reveals no entries for the Project Site.

The subject property is located within 100' of a bordering vegetated wetland, within the 100' riparian zone, and within 100' of a certified vernal pool, as illustrated on the site development plans. It should be noted that there is no proposed work within any of these areas and the SMS utilizes practices that are recommended within close proximity to both cold-water fisheries and certified vernal pools by the MassDEP.

EXISTING WATERSHED DESCRIPTION

Under existing conditions, the site is divided into five (5) watersheds. Watershed E-1 flows north to Wetland "D" (Study Point #1). Watershed E-2 represents water area that flows to Wetland "F" (Study Point #2). Watershed E-3 flows off-site to the southwest (Study Point #3). Watershed E-4 flows south/southwest to Wetland's "A" (Study Point #4). Watershed E-5 represents an existing depression. The Hydro CAD model shows that no water leaves the site from this watershed and therefore a Study Point is not needed. Existing watersheds consist of gravel paths and wooded terrain as the site is undeveloped. Tc's were calculated using Hydro CAD, using 0.1 hours or 6 minutes as the minimum Tc. See the attached Existing Watershed Plan and Existing Hydro CAD reports.

DRAINAGE ANALYSIS METHODOLOGY

A peak rate of runoff will be determined using techniques and data found in the following:

1. Urban Hydrology for Small Watersheds – Technical Release 55 by the United States Department of Agriculture Soils Conservation Service, June 1986. Runoff curve numbers and 24-hour precipitation values were obtained from this reference.
2. Hydro CAD© Stormwater Modeling System by Hydro CAD Software Solutions LLC, version 10.00, 2013. The Hydro CAD program was used to generate the runoff hydrographs for the watershed areas, to determine discharge/ stage/storage characteristics for the stormwater BMPs, to perform drainage routing and to combine the results of the runoff hydrographs. Hydro CAD uses the TR-20 methodology of the SCS Unit Hydrograph procedure (SCS-UH).
3. Soil Survey of Essex County, Massachusetts by United States Department of Agriculture, NRCS. Soil types and boundaries were obtained from this reference.
4. Cornell University Extreme Precipitation Tables – Northeast Regional Climate Center

PROPOSED CONDITIONS – PEAK RATE OF RUNOFF

The storm water runoff analysis of the existing and proposed conditions includes an estimate of the peak rate of runoff from various rainfall events. Peak runoff rates were developed using TR55 Urban Hydrology for Small Watersheds, developed by the U.S. Department of Commerce, Engineering Division and the Hydro CAD computer program. Further, the analysis has been prepared in accordance the Town requirements and standard engineering practices. The peak rate of runoff has been estimated for each watershed during the 2, 10, 25, and 100-year storm events.

The subject property's peak flow rates are analyzed at four (4) Study Points. Study Point #1 represents flows discharging to the Wetland "D". Study Point #2 represents flows to Wetland "F"; Study Point #3 represents flows leaving the site to the southwest; and Study Point #4 represents water flowing to Wetland "A". The site is broken into 18 watersheds in order to model the proposed conditions. See the proposed watershed plan and drainage plans for more information.

Watershed P-1 is located on the north of the proposed entry drive and represents water sheet flowing to the Wetland "D". Watershed consists of grass and woods.

Watershed P-2 is located on the west side of the Site and represents water sheet flowing to Wetland "F". Watershed P-2 consists of grass and woods.

Watershed P-3 is located southwest of the WWTF and represents flows leaving the site to the southwest. This watershed consists of mostly woods, grass, and retaining wall.

Watershed P-4 is located southeast, east, and northeast of the proposed development and represents water discharging to Wetland "A". Watershed P-4 consists of mostly woods with grass and a retaining wall.

Watershed P-5 represents the entrance driveway near School Street, the proposed water pump house, and the abutting bio-retention/rain garden #2. The watershed consists of bituminous pavement and grass and flows to rain garden #2 for treatment.

Watershed P-6 represents the landscaped slope and tiered retaining walls south of the entry drive. This watershed is mostly grass with a small amount of impervious from the retaining walls.

Watershed P-7 represents the 2:1 landscaped slope northwest and west of the proposed building. The watershed is comprised of entirely long/brush grass and will discharge to Bio-retention/Rain Garden #1 for treatment and infiltration.

Watershed P-8 is the cul-de-sac turnaround area located near the garage entrance and consists of mostly pavement with landscaped grass. Watershed P-8 is conveyed via manholes and pipes to Underground Infiltration System #1 (UIS-1).

Watershed P-9 is the north courtyard of the proposed building and will be a green roof design. Watershed P-9 will discharge to UIS-1 via roof drains and manholes.

Watershed P-10, P-11, & P-12 are the proposed building roof areas. P-9 is also considered roof area however it will be a green roof; P-10, P-11, & P-12 will be standard impervious rooftops with flows being conveyed to UIS-1 via roof drains and downspouts.

Watershed P-13 is the main surface parking area for the development and consists of impervious asphalt pavement and landscape islands of grass & trees. P-13 will discharge to UIS-1 via pipes and manholes.

Watershed P-14 represents the southwest lawn area where UIS-1 is located and the driveway southwest of the building. This watershed will consist of pavement and grass and will discharge to UIS-1.

Watershed P-15 is the lawn area and fire access drive southeast of the proposed building and will consist of grass and GrassPave2. GrassPave2 is a proprietary pervious surface that allows for H-20 loading to be applied while also remaining permeable. The GrassPave2 system will be used as a fire access road. This watershed will be conveyed to Bio-retention/Rain Garden #1.

Watershed 16 represents the entry drive, consists of pavement and grass, and will discharge to Bio-retention/Rain Garden #1.

Watershed 17 represents Bio-retention/Rain Garden #1.

Peak Flow Rates

Study Point #1 (Flow to Wetland "D")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	4.52	9.46	13.70	20.50
Proposed Runoff (CFS)	1.82	7.93	12.43	20.37
REDUCTION	2.70	1.53	1.27	0.13

Study Point #2 (Flow to Wetland "F")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	0.86	1.81	2.60	4.27
Proposed Runoff (CFS)	0.80	1.67	2.40	3.94
REDUCTION	0.06	0.14	0.20	0.33

Study Point #3 (Flow southwest off site)

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	0.94	1.91	2.72	4.42
Proposed Runoff (CFS)	0.46	0.91	1.29	2.08
REDUCTION	0.48	1.00	1.43	2.34

Study Point #4 (Flow to 18" RCP in Wetland "A")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	3.23	4.41	5.06	6.01
Proposed Runoff (CFS)	3.23	4.29	4.87	5.78
REDUCTION	0.00	0.12	0.19	0.23

Peak Volumes

Study Point #1 (Flow to Wetland "D")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CF)	18,035	36,681	52,747	87,423
Proposed Runoff (CF)	8,417	29,204	48,847	91,900
DELTA	-9,618	-7,477	-3,900	+4,477

Study Point #2 (Flow to Wetland "F")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CF)	3,269	6,649	9,562	15,848
Proposed Runoff (CF)	2,926	5,952	8,559	14,186
REDUCTION	343	697	1,003	1,662

Study Point #3 (Flow southwest off site)

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CF)	3,013	6,037	8,626	14,190
Proposed Runoff (CF)	1,523	3,007	4,269	6,971
REDUCTION	1,490	3,030	4,357	7,219

Study Point #4 (Flow to 18" RCP in Wetland "A")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CF)	19,162	38,972	56,042	92,883
Proposed Runoff (CF)	17,378	34,567	49,222	80,633
REDUCTION	1,784	4,405	6,820	12,250

MASSDEP STORMWATER PERFORMANCE STANDARDS

The MA DEP Stormwater Management Policy was developed to improve water quality by implementing performance standards for storm water management. The intent is to implement the stormwater management standards through the review of Notice of Intent filings by the issuing authority (Conservation Commission or DEP). The following section outlines how the proposed Stormwater Management System meets the standards set forth by the Policy.

BMPs implemented in the design include –

- Deep-sump, hooded catch basins
- Hydro-dynamic (Proprietary) separators
- Corrugated Metal Pipe (CMP) Subsurface Infiltration System
- Rain Gardens
- Green Roofs
- Specific maintenance schedule

Stormwater Best Management Practices have been incorporated into the design of the project to mitigate the anticipated pollutant loading. An Operations and Maintenance Plan has been developed for the project, which addresses the long-term maintenance requirements of the proposed system.

Temporary erosion and sedimentation controls will be incorporated into the construction phase of the project. These temporary controls may include straw bale and/or silt fence barriers, inlet sediment traps, slope stabilization, and stabilized construction entrances.

The Massachusetts Department of Environmental Protection has established ten (10) Stormwater Management Standards. A project that meets or exceeds the standards is presumed to satisfy the regulatory requirements regarding stormwater management. The

Standards are enumerated below as well as descriptions and supporting calculations as to how the Project will comply with the Standards:

1. *No new stormwater conveyances (e.g., outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.*

   The proposed development will not introduce any new stormwater conveyances (e.g., outfalls) that discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

2. *Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.*

   The proposed development will be designed so that the post-development peak discharge rates and do not exceed the pre-development peak discharge rates. See Peak Flow Rates and Volumes Tables above and the attached Hydro CAD reports.

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

   The existing annual recharge for the site will be exceeded in the developed condition. Some existing soils are not conducive for infiltration as they are comprised of HSG-D soils and there is a certainty of exposed ledge and shallow bedrock on site.

   Not all proposed impervious areas discharge to an infiltrating BMP due to existing site conditions like ledge and a lack of soil test pits. Approximately 9,142 square feet of impervious area near the site entrance cannot be infiltrated due to existing ledge. Volume 3, Chapter 1, Page 27 of the Massachusetts Stormwater handbook offers considerations for Standard 3 in the event not all impervious area can discharge to an infiltration BMP.

   See below for "Captured Area Adjustment" for the total required site recharge (Rv). All other impervious areas are directed to an infiltration BMP.

Total Required Site Recharge (Rv = F x impervious area)

Rv = [(0.1 inches/12 inches/foot) (147,851 sq. ft.) = 1,232 cubic feet

Site area draining to recharge facilities = 506,116 – 18,436 = 487,680 sq. ft.

Ratio of total site area draining to recharge facilities = 506,116/487,680 = 1.03

Adjusted minimum required recharge = [(1.03) x (1,232 cubic feet)] = 1,269 cubic feet.

Provided Recharge Volume (Rv) = 11,872 cubic feet > 1,269 cubic feet

Calculations show that the required recharge for the site is exceeded by Underground Infiltration System-1 and Bio-retention Area/Rain Garden #1.

The subsurface infiltration system will be designed to meet this requirement using the Static Method per the MassDEP Stormwater Management Standards, Volume 3, Chapter 1. See "DEP Calculations" in the Appendix of this report for water quality/recharge calculations.

4. *Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This standard is met when:*
    - *Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;*
    - *Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and*
    - *Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.*

The proposed site is considered a land use with higher potential pollutant loads. With this categorization the 44% TSS removal before it can be discharged to an infiltration system is required for the project. The overall 80% TSS removal standard will be met using some combination of the following: hooded deep-sump catch basins, proprietary hydro-dynamic separators, Bio-retention/Rain Gardens (filtering), and outlet control structure.

The water quality volume for the site development will be captured and treated by a proprietary hydro-dynamic separator before discharging to either an infiltrating BMP or a treatment BMP. During high-intensity storm events, UIS-1 will convey flows to Bio-retention Area/Rain Garden #1. All systems will be sized to meet the water quality flow rate for the 1" storm event. See "DEP Calculations" in the appendix of this report.

Rain Garden #2 will be lined with an impervious PVC barrier to prevent infiltration, as test pits are not available in this area. The Rain Garden will accept pre-treated flows from a water quality unit to further filter/clean the water before discharging to the abutting wetlands.

5. *For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If through source control and/or pollution prevention all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use the specific structural stormwater BMPs determined by the Department to be suitable for such uses as provided in the Massachusetts Stormwater Handbook. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.*

   The proposed development is considered a source of higher potential pollutant loads. The SMS will be designed to treat 1" water quality volume with hydrodynamic separators, deep-sump, hooded catch basins, sub-surface infiltration system, an infiltrating rain garden, and a filtering rain garden.

6. *Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook. A discharge is near a critical area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "storm water discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.*

   The proposed project abuts Sawmill Creek which is considered a Cold-Water Fishery (Mass Mapper). The SMS utilizes BMPs recommended by MassDEP for

Cold-Water Fisheries including proprietary water quality units and bio-retention/rain garden areas.

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

   The proposed project is not considered a re-development project under the Stormwater Management Handbook guidelines as there is an increase in the amount of impervious area.

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

   A plan to control construction-related impacts, including erosion, sedimentation and other pollutant sources during construction and land disturbance activities will be developed. The proponent will prepare and submit a Stormwater Pollution Prevention Plan (SWPPP) prior to commencement of construction activities that will result in the disturbance of one acre of land or more.

9. *A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.*

   A Long-Term Operation & Maintenance (O&M) Plan has been developed for the proposed stormwater management system and is included within this document. See Section 2.0 of this report.

10. *All illicit discharges to the stormwater management system are prohibited.*

    There are no expected illicit discharges to the stormwater management system. The Applicant has submitted the Illicit Discharge Compliance Statement with this report.

See the next page for the MassDEP Stormwater Checklist.

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.

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[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.

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
CARLTON M. QUINN
CIVIL
No 49923
REGISTERED
PROFESSIONAL ENGINEER

3.23.22

Signature and Date

Checklist

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

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

- ☒ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☐ Reduced Impervious Area (Redevelopment Only)
- ☐ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☐ Use of "country drainage" versus curb and gutter conveyance and pipe
- ☒ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☐ Grass Channel
- ☒ Green Roof
- ☒ Other (describe): Water quality units, 96" CMP infiltration system.

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 (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist (continued)

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

☐ 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 (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☒ An Illicit Discharge Compliance Statement is attached;

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

SECTION 2.0 –
OPERATION & MAINTENANCE

OPERATIONS AND MAINTENANCE PLAN

In accordance with the standards set forth by the Stormwater Management Policy issued by the Department of Environmental Protection (DEP), Allen & Major Associates, Inc. (A&M) has prepared the following Operation and Maintenance plan for the drainage improvements located at 0 School Street in Manchester-by-the-Sea, MA (The Sanctuary at Manchester-by-the-Sea).

This plan is broken into two major sections. The first section describes construction-related erosion and sedimentation controls. The second section is devoted to a post-development operation and maintenance plan. An operation and maintenance schedule is included with this report.

Stormwater Management System Owner:	SLV School Street, LLC. 257 Hillside Avenue Newton, MA 02494

Emergency Contact Information:

SLV School Street, LLC. c/o Geoff Engler	Phone: (617) 276-7261
Allen & Major Associates, Inc. (Civil)	Phone: (781) 935-6889
Manchester-by-the-Sea DPW	Phone: (978) 526-1242
Manchester-by-the-Sea Fire Department	Phone: (978) 526-4040
Manchester-by-the-Sea Con. Commission	Phone: (978) 526-4397

INTRODUCTION

The stormwater management system (SMS) for this project is owned by SLV School Street, LLC. (or current owner), and shall be legally responsible for long-term operation and maintenance for this SMS as outlined in this Operation and Maintenance (O&M) Plan. Should ownership of the SMS change, the succeeding owner will be presented with this O&M Plan and supporting attachments at or before legal conveyance of ownership and will assume the obligations of the O&M Plan.

In the event that the SMS will be operated and maintained by an entity other than that listed in this document, the applicant shall provide a plan and easement deed that provides a right of access for the legal entity to be able to perform said operation and maintenance functions. In the event the SMS will serve multiple lots/owners, the applicant shall also provide 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 entire SMS.

DEMOLITION & CONSTRUCTION MAINTENANCE PLAN

1. Call Digsafe: 1-888-344-7233
2. Contact the Town at least three (3) days prior to start of demolition and/or construction activities.
3. Install Erosion Control measures as shown on the Plans prepared by A&M. The Town shall review the installation of straw bales and silt fencing prior to the start of any site demolition work. Install Construction fencing if determined to be necessary at the commencement of construction.
4. Install construction entrances, straw bales, and silt fence at the locations shown on the Erosion Control Plan prepared by A&M.
5. Site access shall be achieved only from the designated construction entrances.
6. Cut and clear trees in construction areas only (within the limit of work; see plans).
7. Stockpiles of materials subject to erosion shall be stabilized with erosion control matting or temporary seeding whenever practicable, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.
8. Install silt sacks and straw bales around each drain inlet prior to any demolition and or construction activities.
9. All erosion control measures shall be inspected weekly and after every rainfall event. Records of these inspections shall be kept on-site for review.
10. All erosion control measures shall be maintained, repaired, or replaced as required or at the direction of the owner’s engineer or the Town.
11. Sediment accumulation up-gradient of the straw bales, silt fence, and stone check dams greater than 6” in depth shall be removed and disposed of in accordance with all applicable regulations.
12. If it appears that sediment is exiting the site, silt sacks shall be installed in all catch basins adjacent to the site. Sediment accumulation on all adjacent catch basin inlets shall be removed and the silt sack replaced if torn or damaged.
13. Install stone check dams on-site during construction as needed. Refer to the erosion control details. Temporary sediment basins combined with stone check damns shall be installed on-site during construction to control and collect runoff from upland areas of this site during demolition and construction activities.

14. The contractor shall comply with the Sedimentation and Erosion Control Notes as shown on the Site Development Plans and Specifications.
15. The stabilized construction entrances shall be inspected weekly and records of inspections kept. The entrances shall be maintained by adding additional clean, angular, durable stone to remove the soil from the construction vehicle's tires when exiting the site. If soil is still leaving the site via the construction vehicle tires, adjacent roadways shall be kept clean by street sweeping.
16. Dust pollution shall be controlled using on-site water trucks and/or an approved soil stabilization product.
17. During demolition and construction activities, Status Reports on compliance with this O&M Document shall be submitted weekly. The report shall document any deficiencies and corrective actions taken by the applicant.

POST CONSTRUCTION MAINTENANCE PLAN

The SMS shall be inspected immediately after construction. A maintenance log will be kept (i.e., report) summarizing inspections, maintenance, and any corrective actions taken. The log will include the date on which each inspection or maintenance task was performed, a description of the inspection findings or maintenance completed, and the name of the inspector or maintenance personnel performing the task. If a maintenance task requires the clean-out of any sediments or debris, the location where the sediment and debris was disposed after removal will be indicated. The log will be made accessible to department staff and a copy provided to the department upon request.

Inspection and Maintenance Frequency and Corrective Measures

The following areas, facilities, and measures will be inspected and the identified deficiencies will be corrected. Clean-out must include the removal and legal disposal of any accumulated sediments, trash, and debris. In any and all cases, operations, inspections, and maintenance activities shall utilize best practical measures to avoid and minimize impacts to wetland resource areas outside the foot print of the SMS.

SMS components that will require continuing inspection as outlined in the document:

- *Deep-Sump Catch Basins*
- *Proprietary Separators*
- *Outlet Control Structures*
- *Sub-Surface Infiltration Systems*
- *Bio-retention Areas/Rain Gardens (exfiltrating & filtering only)*
- *Snow Storage*

Monthly Post Construction Inspection (first three months only)

- **Surface Infiltration Systems**: Inspect the infiltration system after all rainfalls greater than 1″ to ensure that the system is draining within 72 hours. Repair as required.

- **Bioretention Areas (Areas #2):** Inspect the Bioretention Areas after all rainfalls greater than 1″ to ensure that the areas are draining within 72 hours. Repair as required.

- **Drainage Swale (next to entry drive):** Inspect the swale after all rainfalls greater than 1″ to ensure that the swale is draining. Repair as required.

- **Sub-surface Infiltration Systems:** Inspect the Infiltration system after all rainfalls greater than 1″ to ensure that the system is draining within 72 hours. Repair as required.

Quarterly Inspections (specifically after foliage and snow season)

- **Deep Sump Catch Basins**: Inspect catch basins to ensure that the catch basins are working in their intended fashion and that they are free of debris. Structures will be skimmed of floatable debris at each inspection and sediment will be removed at a minimum once per year (typically after snow season) or when sediment has accumulated to within 2 feet of the outlet invert. If the basin outlet is designed with a hood to trap floatable materials (i.e., Snout), check to ensure watertight seal is working.
- **Bioretention Areas:** Inspect overflow pipes to determine if they are clogged. Remove accumulated sediment, trash, debris, leaves and grass clippings from mowing. Remove tree seedlings, before they become firmly established.

- **Drainage Swale (next to entry drive):** Inspect the swale 24 hours or several days after large rain events (greater than 1.5″), to look for ponded water. If there is ponded water at the surface of the swale, it is likely that the grass and pea stone filter strip are clogged. To address surface clogging, remove the sediment and replace the first layer of pea stone on the filter strip. If water is ponded inside the swale, it may indicate that the bottom of the swale has failed. To rehabilitate a failed swale, all accumulated sediment must be stripped from the bottom, the bottom of the swale must be scarified and tilled to induce infiltration, and all of the stone aggregate must be removed and replaced.
- **Proprietary Separators**: Separators shall be operated in strict accordance with manufacturer's recommended practices. Available manufacturer specific O&M plans attached as Appendix. Separators shall be inspected to ensure that they are

working in their intended fashion and that they are free of debris. Structures shall be cleaned with a vacuum truck at least once annually (typically after snow season) or when sediment has accumulated to a depth of six inches (6"), whichever is more frequent.

- **Surface Infiltration Systems**: The surface ponds will be inspected 24 hours or several days after large rain events (greater than 1.5"), to look for ponded water. Pond should be inspected and the trashed removed on a monthly basis. The basin should be mowed a minimum of two (2) times per year and a maximum of once monthly.

Semi-Annual Inspection (specifically after foliage and snow season)

- **Culverts**: Inspect culverts to ensure that the culverts are working in their intended fashion and that they are free of debris. Remove any obstructions to flow; remove accumulated sediments and debris at the inlet, at the outlet, and within the conduit and to repair any erosion damage at the culvert's inlet and outlet.
- **Vegetated Areas:** Inspect slopes and embankments early in the growing season to identify active or potential erosion problems. Replant bare areas or areas with sparse growth. Where rill erosion is evident, armor the area with an appropriate lining or divert the erosive flows to on-site areas able to withstand the concentrated flows.
- **Roadway and Parking Surfaces:** Sweep paved areas as soon as possible after snow melt and no less than four times annually. Clear accumulations of winter sand in parking lots and along roadways at least once a year, preferably in the spring. Accumulations on pavement may be removed by pavement sweeping. Accumulations of sand along road shoulders may be removed by grading excess sand to the pavement edge and removing it manually or by a front-end loader.
- **Level Spreaders, Check Dams, Rip-Rap:** These accessories will be inspected for erosion, debris accumulation, and unwanted vegetation. Erosion will be stabilized and sediment, debris, and woody vegetation will be removed.

Annual Maintenance (specifically during the growing season)

- **Bioretention Areas:**
  Mulch and vegetation should be refreshed, pruned, or replaced. Any undesirable woody vegetation or accumulated sediment must be removed.

LANDSCAPE MANAGEMENT PLAN

It should be recognized that this is a general guideline towards achieving high quality and well-groomed landscaped areas. The grounds staff / landscape contractor must recognize the shortcomings of a general maintenance plan such as this, and modify and/or augment it based on weekly, monthly, and yearly observations to tailor the specifics of the site. In order to ensure the highest quality conditions, the staff must also recognize and appreciate the need to be aware of the constantly changing conditions of the landscaping and be able to respond to them on a proactive basis.

Lawn Fertilizer: Maintenance practices should be aimed at reducing environmental, mechanical and pest stresses to promote healthy and vigorous growth. When necessary, pest outbreaks should be treated with the most sensitive control measure available. Synthetic chemical controls should be used only as a last resort to organic and biological control methods. Fertilizer, synthetic chemical controls and pest management applications (when necessary) shall be performed only by licensed applicators in accordance with the manufacturer's label instructions when environmental conditions are conducive to controlled product application.

If possible, try to use slow-release organic fertilizers should be used in the planting and mulch areas to limit the amount of nutrients that could enter downstream resource areas. Fertilization of the planting and mulch areas will be performed within manufacturers labeling instructions and shall not exceed an NPK ration of 1:1:1 (i.e., Triple 10 fertilizer mix), considered a low nitrogen mixture

MANAGEMENT OF DEICING CHEMICALS AND SNOW

Snow shall not be plowed towards any area protected by the Massachusetts Wetlands Protection Act. Additionally, it is prohibited to dump snow into the infiltration basin or near the abutting vegetated wetlands. Snow shall only be stockpiled on site within the snow storage areas depicted on the Snow Storage Plan. If the stockpiles of snow do not fit within the designated areas, then snow will be disposed off-site. It will be the responsibility of the snow removal contractor to properly dispose of transported snow according to the most recent Superseded Massachusetts Department of Environmental Protection, Bureau of Resource Protection – Snow Disposal Guideline #BRPG01-01 effective December 23, 2019, governing the proper disposal of snow. It will be the responsibility of the snow removal contractor to follow these guidelines and all applicable laws and regulations. A copy of the MassDEP Snow Disposal Guideline #BRPG01-01 has been included at the end of Section 2 for reference.

The site's maintenance staffs (or its designee) will be responsible for the clearing of the sidewalk and building entrances. The site may be required to use a de-icing agent such as potassium chloride (or approved equal) to maintain a safe walking surface; however, these are to be used at the minimum amount practicable. The de-icing agent for the walkways and building entrances will be kept within the storage rooms located within the buildings. De-icing agents will not be stored outside.

SPILL PREVENTION AND RESPONSE

Sources of potential spill hazards include vehicle fluids, liquid fuels, pesticides, paints, solvents, and liquid cleaning products. The majority of the spill hazards would likely occur within the building and would not enter the stormwater drainage system. However, there are spill hazards from vehicle fluids or liquid fuels located outside of the buildings. These exterior spill hazards have the potential to enter the stormwater drainage system and are to be addressed as follows:

- *Spill Hazards of pesticides, paints, and solvents shall be remediated using the Manufacturers' recommended spill cleanup protocol.*
- *Vehicle fluids and liquid fuel spill shall be remediated according to the local and state regulations governing fuel spills.*
- *The owner shall have the following equipment and materials on hand to address a spill clean-up: brooms, dust pans, mops, rags, gloves, absorptive material, sand, sawdust, plastic and metal trash containers.*
- *All spills shall be cleaned up immediately after discovery.*
- *Spills of toxic or hazardous material shall be reported, regardless of size, to the Massachusetts Department of Environmental Protection at 888-304-1133.*
- *Should a spill occur, the pollution prevention plan will be adjusted to include measures to prevent another spill of a similar nature. A description of the spill, along with the causes and cleanup measures will be included in the updated pollution prevention plan.*

OPERATION & MAINTENANCE PLAN SCHEDULE

Project: The Sanctuary
Address: 0 School Street
Manchester-by-the-Sea

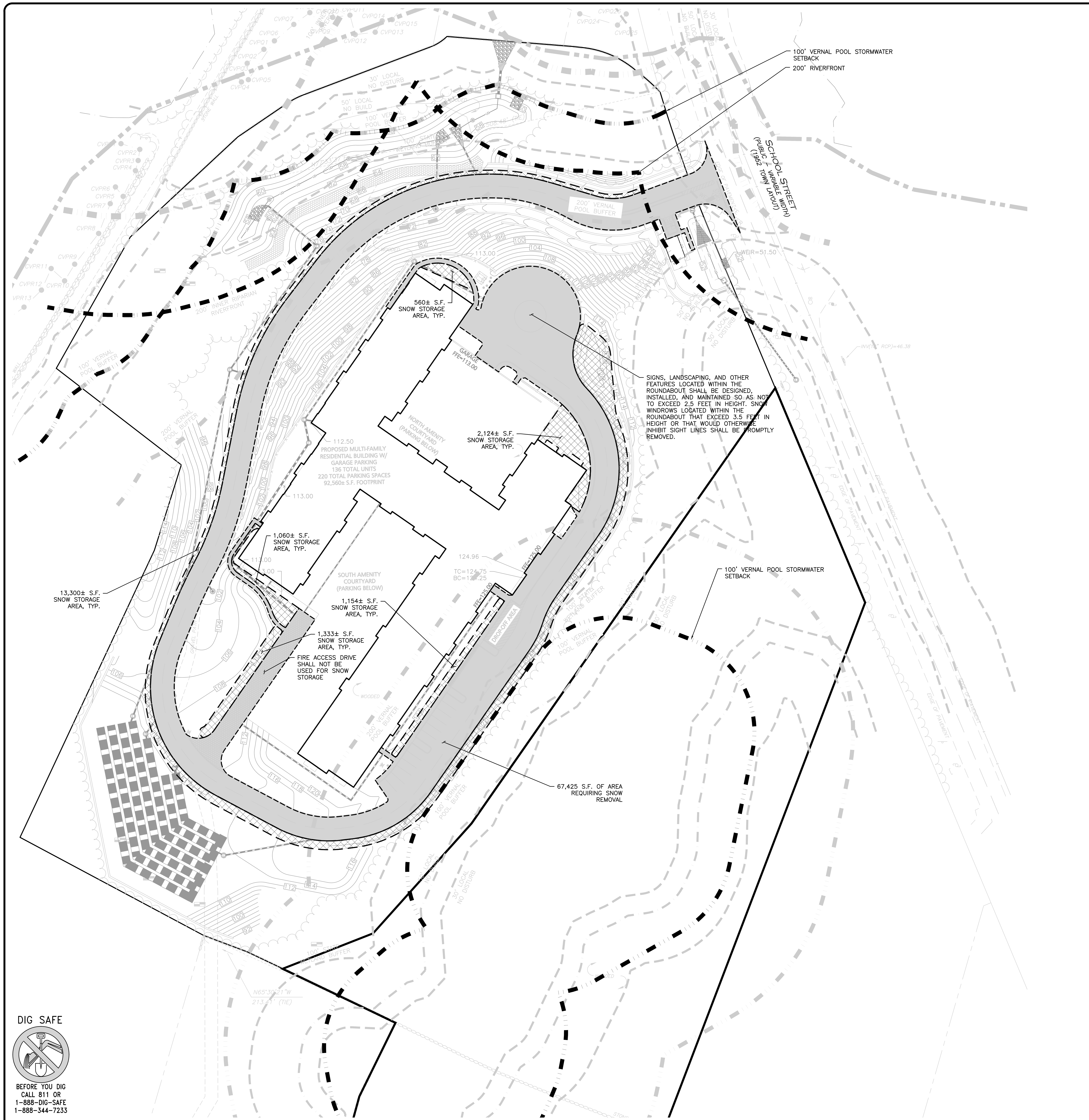
ty Responsible for O & M Plan: SLV School Street, LLC.
Address: 257 Hillside Avenue
Needham, MA 02494

Phone:

Date: 7/16/2021
Revised: 3/23/2022

Structure or Task	Maintenance Activity	Schedule/Notes	Annual Maintenance Cost	Inspection Performed Date:	Inspection Performed By:
Street Sweeping	Sweep, power broom or vacuum paved areas.	Sweep paved areas as needed, but not less than four times annually.	$2,000		
		Submit information that confirms that all street sweepings have been disposed in accordance with state and local requirements			
Deep Sump Catch Basins(s)	Clam shell or vacuum sumps	Inspect at least twice annually. Clean when sediment is within 2.5 feet of the outlet invert.	$500		
		Submit information that confirms that all catch basin sediments have been disposed in accordance with state and local requirements			
Storm Water Management System					
Proprietary Separators	See the ConTECH Maintenance package for the inspection and cleaning procedure.	Inspect at least four times annually as well as following storms exceeding 1" of rainfall. Devices shall be cleaned at leaast once annually or when sediment reaches 6 inches of depth whichever is more frequent. See also note #1 below.	$250		
		Submit information that confirms that all water quality inlets sediments have been disposed in accordance with state and local requirements			
Rain Gardens	Inspect & remove trash	Monthly during all seasons	$250		
	Mulch	Annually every spring			
	Remove/Replace dead vegetation	Annually. Remove in fall & spring, replace in spring only			
	Prune	Anually as-needed, spring or fall			
	Replace media & all vegetation	Late spring/early summer, as-needed			
Sub-Surface Detention/Infiltration Ponds	Inspect monthly and after large storm events to ensure it is draining properly.	On a semi-annual basis.	$500		
	The surface pond will be inspected 24 hours or several days after large rain events (greater than 1.5"), to look for ponded water. Pond should be inspected and the trashed removed on a monthly basis. The basin should be mowed a minimum of two (2) times per year and a maximum of once monthly.				
Outlet Control Structure(s)	Clam shell or vacuum sumps	Periodic cleaning of Outlet Control Structures as needed.	$50		
Pool Water Discharge	CB management targeted larviciding treatment to CB's and all storm drains to control mosquitoes in their aquatic stages.	Pool water shall not be or drainage structures under any circumstances.	N/A		
Mosquito Control	CB management targeted larviciding treatment to CB's and all storm drains to control mosquitoes in their aquatic stages.	Surveillance is a non chemical inspection method that involves classification of mosquito breeding sites, larval presents, and survey.	$100		
Snow Storage	Debris shall be cleared from the site and properly disposed of at the end of the snow season, but shall be cleared no later than May 15.	Avoid dumping snow removal over catch basins, in detention ponds, sediment forebays, rivers, wetlands, and flood plain. It is also prohibited to dump snow in the bioretention basins or gravel	$500		

Note #1 - During the first year of operation, all of the BMP's shall be inspected during and after large storm events to ensure they are functioning properly. The surface infiltration pond should be fully drained within 72 hours after a rain event. If it is not drained within this time period, the systems shall be evaluated and corrective actions should be implemented.



LEGEND

AREAS REQUIRING SNOW REMOVAL	
PRIMARY SNOW STORAGE AREAS	

NOTES:

1. THE PROPOSED PROJECT AREA HAS APPROXIMATELY 67,500 S.F. OF PAVED VEHICULAR AREA, SIDEWALK AND FIRE ACCESS LANES THAT WILL NEED SNOW REMOVAL.

2. THE PLAN DEPICTS APPROXIMATELY 18,000 S.F. OF AREA AVAILABLE FOR PRIMARY SNOW STORAGE WITHIN THE PROJECT AREA. THE AREA IS ESTIMATED TO ACCOMMODATE AN APPROXIMATE 5.33' OF SNOWFALL, ASSUMING A 5:1 COMPACTION AND AN AVERAGE SNOW PILE HEIGHT OF 4.0'. ADDITIONAL SNOW SECONDARY SNOW STORAGE AREAS ARE AVAILABLE ON–SITE IS NECESSARY.

3. IT IS UNLIKELY THIS PROJECT WOULD NEED SNOW TO BE REMOVED OFF–SITE, BUT IF NECESSARY: SNOW WILL BE STOCKPILED ON SITE UNTIL THERE IS NOT ENOUGH SPACE. AS NECESSARY, THE SNOW WILL BE REMOVED AND DISPOSED OF OFF–SITE. IT WILL BE THE RESPONSIBILITY OF THE SNOW REMOVAL CONTRACTOR TO PROPERLY DISPOSE OF TRANSPORTED SNOW ACCORDING TO MASSACHUSETTS DEP, BUREAU OF RESOURCE PROTECTION – MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION BUREAU OF WATER RESOURCES SNOW DISPOSAL GUIDANCE EFFECTIVE DATE: DECEMBER 23, 2019, GOVERNING THE PROPER DISPOSAL OF SNOW. IT WILL BE THE RESPONSIBILITY OF THE SNOW REMOVAL CONTRACTOR TO FOLLOW THESE GUIDELINES AND ALL APPLICABLE LAWS AND REGULATIONS.

4. UNDER NO CIRCUMSTANCES SHALL SNOW BE STORED IN ANY WETLAND RESOURCE AREA OF PROPOSED STORMWATER MANAGEMENT SYSTEM.

5. SNOW STORAGE WILL BE IMPLEMENTED TO AVOID HYDRANTS, FENCES LANDSCAPING AND OTHER PERMANENT FEATURES.

GRAPHIC SCALE

40 0 20 40 80 160

(IN FEET)
1 inch = 40 ft.

N:\PROJECTS\2725-01\CIVIL\DRAWINGS\CURRENT\C-2725-01_SNOW STORAGE.DWG

COMMONWEALTH OF MASSACHUSETTS
CARLTON M. QUINN
CIVIL
No.49923
REGISTERED PROFESSIONAL ENGINEER

PROFESSIONAL ENGINEER FOR ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION
A	03-23-2022	REVISED PER COMMENTS

APPLICANT\OWNER:

SLV SCHOOL STREET, LLC
257 HILLSIDE AVENUE
NEEDHAM, MA 02494

PROJECT:

THE SANCTUARY
SCHOOL STREET
MANCHESTER-BY-THE-SEA, MA

PROJECT NO.	2725-01	DATE:	03-23-2022
SCALE:	1"=40'	DWG. NAME:	C-2725-01
DESIGNED BY:	CMQ/SJL	CHECKED BY:	CMQ

PREPARED BY:

ALLEN & MAJOR ASSOCIATES, INC.
civil engineering ◆ land surveying
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DRAWING TITLE: SNOW STORAGE PLAN

SHEET No. C-106

MassDEP
Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

One Winter Street Boston, MA 02108 • 617-292-5500

Massachusetts Department of Environmental Protection
Bureau of Water Resources
Snow Disposal Guidance

Effective Date: December 23, 2019

Applicability: Applies to all federal, state, regional and local agencies, as well as to private businesses.

Supersedes: Bureau of Resource Protection (BRP) Snow Disposal Guideline No. BRPG97-1 issued December 12, 1997 and BRPG01-01 issued March 8, 2001; Bureau of Water Resources (BWR) snow disposal guidance issued December 21, 2015 and December 12, 2018.

Approved by: Kathleen Baskin, Assistant Commissioner, Bureau of Water Resources

PURPOSE: To provide guidelines to all government agencies and private businesses regarding snow disposal site selection, site preparation and maintenance, and emergency snow disposal options that are protective of wetlands, drinking water, and water bodies, and are acceptable to the Massachusetts Department of Environmental Protection (MassDEP), Bureau of Water Resources.

APPLICABILITY: These Guidelines are issued by MassDEP's Bureau of Water Resources on behalf of all Bureau Programs (including Drinking Water Supply, Wetlands and Waterways, Wastewater Management, and Watershed Planning and Permitting). They apply to all federal agencies, state agencies, state authorities, municipal agencies and private businesses disposing of snow in the Commonwealth of Massachusetts.

INTRODUCTION

Finding a place to dispose of collected snow poses a challenge to municipalities and businesses as they clear roads, parking lots, bridges, and sidewalks. While MassDEP is aware of the threats to public safety caused by snow, collected snow that is contaminated with road salt, sand, litter, and automotive pollutants such as oil also threatens public health and the environment.

As snow melts, road salt, sand, litter, and other pollutants are transported into surface water or through the soil where they may eventually reach the groundwater. Road salt and other pollutants can contaminate water supplies and are toxic to aquatic life at certain levels. Sand washed into waterbodies can create sand bars or fill in wetlands and ponds, impacting aquatic life, causing flooding, and affecting our use of these resources.

There are several steps that communities can take to minimize the impacts of snow disposal on public health and the environment. These steps will help communities avoid the costs of a contaminated water supply, degraded waterbodies, and flooding. Everything that occurs on the land has the potential to impact the Commonwealth's water resources. Given the authority of local government over the use of the land, municipal officials and staff have a critically important role to play in protecting our water resources.

The purpose of these guidelines is to help federal agencies, state agencies, state authorities, municipalities and businesses select, prepare, and maintain appropriate snow disposal sites before the snow begins to accumulate through the winter. Following these guidelines and obtaining the necessary approvals may also help municipalities in cases when seeking reimbursement for snow disposal costs from the Federal Emergency Management Agency is possible.

RECOMMENDED GUIDELINES

These snow disposal guidelines address: (1) site selection; (2) site preparation and maintenance; and (3) emergency snow disposal.

1. SITE SELECTION

The key to selecting effective snow disposal sites is to locate them adjacent to or on pervious surfaces in upland areas or upland locations on impervious surfaces away from water resources and drinking water wells. At these locations, the snow meltwater can filter into the soil, leaving behind sand and debris which can be removed in the spring. The following conditions should be followed:

- Within water supply Zone A and Zone II, avoid storage or disposal of snow and ice containing deicing chemicals that has been collected from streets located outside these zones. Municipalities may have a water supply protection land use control that prohibits the disposal of snow and ice containing deicing chemicals from outside the Zone A and Zone II, subject to the Massachusetts Drinking Water Regulations at 310 CMR 22.20C and 310 CMR 22.21(2).
- Avoid storage or disposal of snow or ice in Interim Wellhead Protection Areas (IWPA) of public water supply wells, and within 75 feet of a private well, where road salt may contaminate water supplies.
- Avoid dumping snow into any waterbody, including rivers, the ocean, reservoirs, ponds, or wetlands. In addition to water quality impacts and flooding, snow disposed of in open water can cause navigational hazards when it freezes into ice blocks.
- Avoid dumping snow on MassDEP-designated high and medium-yield aquifers where it may contaminate groundwater.
- Avoid dumping snow in sanitary landfills and gravel pits. Snow meltwater will create more contaminated leachate in landfills posing a greater risk to groundwater, and in gravel pits, there is little opportunity for pollutants to be filtered out of the meltwater because groundwater is close to the land surface.

- Avoid disposing of snow on top of storm drain catch basins or in stormwater drainage systems including detention basins, swales or ditches. Snow combined with sand and debris may block a stormwater drainage system, causing localized flooding. A high volume of sand, sediment, and litter released from melting snow also may be quickly transported through the system into surface water.

Recommended Site Selection Procedures

It is important that the municipal Department of Public Works or Highway Department, Conservation Commission, and Board of Health work together to select appropriate snow disposal sites. The following steps should be taken:

- Estimate how much snow disposal capacity may be needed for the season so that an adequate number of disposal sites can be selected and prepared.
- Identify sites that could potentially be used for snow disposal, such as municipal open space (e.g., parking lots or parks).
- Select sites located in upland locations that are not likely to impact sensitive environmental resources first.
- If more storage space is still needed, prioritize the sites with the least environmental impact (using the site selection criteria, and local or MassGIS maps as a guide).

Snow Disposal Mapping Assistance

MassDEP has an online mapping tool to assist in identifying possible locations to potentially dispose of snow. MassDEP encourages municipalities to use this tool to identify possible snow disposal options. The tool identifies wetland resource areas, public drinking water supplies and other sensitive locations where snow should not be disposed. The tool may be accessed through the Internet at the following web address:
https://maps.env.state.ma.us/dep/arcgis/js/templates/PSF/.

2. SITE PREPARATION AND MAINTENANCE

In addition to carefully selecting disposal sites before the winter begins, it is important to prepare and maintain these sites to maximize their effectiveness. The following maintenance measures should be undertaken for all snow disposal sites:

- A silt fence or equivalent barrier should be placed securely on the downgradient side of the snow disposal site.
- Wherever possible maintain a 50-foot vegetated buffer between the disposal site and adjacent waterbodies to filter pollutants from the meltwater.
- Clear debris from the site prior to using the site for snow disposal.
- Clear debris from the site and properly dispose of it at the end of the snow season, and no later than May 15.

3. SNOW DISPOSAL APPROVALS

Proper snow disposal may be undertaken through one of the following approval procedures:

- Routine snow disposal – Minimal, if any, administrative review is required in these cases when upland and pervious snow disposal locations or upland locations on impervious surfaces that have functioning and maintained stormwater management systems have been identified, mapped, and used for snow disposal following ordinary snowfalls. Use of upland and pervious snow disposal sites avoids wetland resource areas and allows snow meltwater to recharge groundwater and will help filter pollutants, sand, and other debris. This process will address the majority of snow removal efforts until an entity exhausts all available upland snow disposal sites. The location and mapping of snow disposal sites will help facilitate each entity's routine snow management efforts.
- Emergency Certifications – If an entity demonstrates that there is no remaining capacity at upland snow disposal locations, local conservation commissions may issue an Emergency Certification under the Massachusetts Wetlands Protection regulations to authorize snow disposal in buffer zones to wetlands, certain open water areas, and certain wetland resource areas (i.e. within flood plains). Emergency Certifications can only be issued at the request of a public agency or by order of a public agency for the protection of the health or safety of citizens, and are limited to those activities necessary to abate the emergency. See 310 CMR 10.06(1)-(4). Use the following guidelines in these emergency situations:
    - Dispose of snow in open water with adequate flow and mixing to prevent ice dams from forming.
    - Do not dispose of snow in salt marshes, vegetated wetlands, certified vernal pools, shellfish beds, mudflats, drinking water reservoirs and their tributaries, Zone IIs or IWPAs of public water supply wells, Outstanding Resource Waters, or Areas of Critical Environmental Concern.
    - Do not dispose of snow where trucks may cause shoreline damage or erosion.
    - Consult with the municipal Conservation Commission to ensure that snow disposal in open water complies with local ordinances and bylaws.
- Severe Weather Emergency Declarations – In the event of a large-scale severe weather event, MassDEP may issue a broader Emergency Declaration under the Wetlands Protection Act which allows federal agencies, state agencies, state authorities, municipalities, and businesses greater flexibility in snow disposal practices. Emergency Declarations typically authorize greater snow disposal options while protecting especially sensitive resources such as public drinking water supplies, vernal pools, land containing shellfish, FEMA designated floodways, coastal dunes, and salt marsh. In the event of severe winter storm emergencies, the snow disposal site maps created by municipalities will enable MassDEP and the Massachusetts Emergency Management Agency (MEMA) in helping communities identify appropriate snow disposal locations.

  If upland disposal sites have been exhausted, the Emergency Declaration issued by MassDEP allows for snow disposal near water bodies. In these situations, a buffer of at least 50 feet, preferably vegetated, should still be maintained between the site and the waterbody. Furthermore, it is essential that the other guidelines for preparing and maintaining snow disposal sites be followed to minimize the threat to adjacent waterbodies.

Under extraordinary conditions, when all land-based snow disposal options are exhausted, the Emergency Declaration issued by MassDEP may allow disposal of snow in certain waterbodies under certain conditions. ***A federal agency, state agency, state authority, municipality or business seeking to dispose of snow in a waterbody should take the following steps***:

- Call the emergency contact phone number [(888) 304-1133)] and notify the MEMA of the municipality's intent.
- MEMA will ask for some information about where the requested disposal will take place.
- MEMA will confirm that the disposal is consistent with MassDEP's Severe Weather Emergency Declaration and these guidelines and is therefore approved.

During declared statewide snow emergency events, MassDEP's website will also highlight the emergency contact phone number [(888) 304-1133)] for authorizations and inquiries. For further non-emergency information about this Guidance you may contact your MassDEP Regional Office Service Center:

Northeast Regional Office, Wilmington, 978-694-3246
Southeast Regional Office, Lakeville, 508-946-2714
Central Regional Office, Worcester, 508-792-7650
Western Regional Office, Springfield, 413-755-2114

Chapter 5
Miscellaneous Stormwater Topics

Mosquito Control in Stormwater Management Practices

Both aboveground and underground stormwater BMPs have the potential to serve as mosquito breeding areas. Good design, proper operation and maintenance and treatment with larvicides can minimize this potential.

EPA recommends that stormwater treatment practices dewater within 3 days (72 hours) to reduce the number of mosquitoes that mature to adults, since the aquatic stage of many mosquito species is 7 to 10 days. Massachusetts has had a 72-hour dewatering rule in its Stormwater Management Standards since 1996. The 2008 technical specifications for BMPs set forth in Volume 2, Chapter 2 of the Massachusetts Stormwater Handbook also concur with this practice by requiring that all stormwater practices designed to drain do so within 72 hours.

Some stormwater practices are designed to include permanent wet pools. These practices – if maintained properly – can limit mosquito breeding by providing habitat for mosquito predators. Additional measures that can be taken to reduce mosquito populations include increasing water circulation, attracting mosquito predators by adding suitable habitat, and applying larvicides.

The Massachusetts State Reclamation and Mosquito Control Board (SRMCB), through the Massachusetts Mosquito Control Districts, can undertake further mosquito control actions specifically for the purpose of mosquito control pursuant to Massachusetts General Law Chapter 252. The Mosquito Control Board, http://www.mass.gov/agr/mosquito/, describes mosquito control methods and is in the process of developing guidance documents that describe Best Management Practices for mosquito control projects.

The SRMCB and Mosquito Control Districts are not responsible for operating and maintaining stormwater BMPs to reduce mosquito populations. The owners of property that construct the stormwater BMPs or municipalities that “accept” them through local subdivision approval are responsible for their maintenance.[1] The SRMCB is composed of officials from MassDEP, Department of Agricultural Resources, and Department of Conservation and Recreation. The nine (9) Mosquito Control Districts overseen by the SRMCB are located throughout Massachusetts, covering 176 municipalities.

Construction Period Best Management Practices for Mosquito Control

To minimize mosquito breeding during construction, it is essential that the following actions be taken to minimize the creation of standing pools by taking the following actions:

- ***Minimize Land Disturbance:*** Minimizing land disturbance reduces the likelihood of mosquito breeding by reducing silt in runoff that will cause construction period controls to clog and retain standing pools of water for more than 72 hours.
- ***Catch Basin inlets:*** Inspect and refresh filter fabric, hay bales, filter socks or stone dams on a regular basis to ensure that any stormwater ponded at the inlet drains within 8 hours after precipitation stops. Shorter periods may be necessary to avoid hydroplaning in roads

[1] MassDEP and MassHighway understand that the numerous stormwater BMPs along state highways pose a unique challenge. To address this challenge, the 2004 MassHighway Stormwater Handbook will provide additional information on appropriate operation and maintenance practices for mosquito control when the Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards..

caused by water ponded at the catch basin inlet. Treat catch basin sumps with larvicides such as *Bacillus sphaericus* (*Bs*) using a licensed pesticide applicator.

- ***Check Dams:*** If temporary check dams are used during the construction period to lag peak rate of runoff or pond runoff for exfiltration, inspect and repair the check dams on a regular basis to ensure that any stormwater ponded behind the check dam drains within 72 hours.
- ***Design construction period sediment traps*** to dewater within 72 hours after precipitation. Because these traps are subject to high silt loads and tend to clog, treat them with the larvicide *Bs* after it rains from June through October, until the first frost occurs.
- ***Construction period open conveyances:*** When temporary manmade ditches are used for channelizing construction period runoff, inspect them on a regular basis to remove any accumulated sediment to restore flow capacity to the temporary ditch.
- ***Revegetating Disturbed Surfaces:*** Revegetating disturbed surfaces reduces sediment in runoff that will cause construction period controls to clog and retain standing pools of water for greater than 72 hours.
- ***Sediment fences/hay bale barriers:*** When inspections find standing pools of water beyond the 24-hour period after a storm, take action to restore barrier to its normal function.

<u>Post-Construction Stormwater Treatment Practices</u>

- Mosquito control begins with the environmentally sensitive site design. Environmentally sensitive site design that minimizes impervious surfaces reduces the amount of stormwater runoff. Disconnecting runoff using the LID Site Design credits outlined in the Massachusetts Stormwater Handbook reduces the amount of stormwater that must be conveyed to a treatment practice. Utilizing green roofs minimizes runoff from smaller storms. Storage media must be designed to dewater within 72 hours after precipitation.
- Mosquito control continues with the selection of structural stormwater BMPs that are unlikely to become breeding grounds for mosquitoes, such as:
    - ***Bioretention Areas/Rain Gardens/Sand Filter:*** These practices tend not to result in mosquito breeding. If any level spreaders, weirs or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
    - ***Infiltration Trenches:*** This practice tends not to result in mosquito breeding. If any level spreaders, weirs, or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
- Another mosquito control strategy is to select BMPs that can become habitats for mosquito predators, such as:
    - ***Constructed Stormwater Wetlands:*** Habitat features can be incorporated in constructed stormwater wetlands to attract dragonflies, amphibians, turtles, birds, bats, and other natural predators of mosquitoes.
    - ***Wet Basins:*** Wet basins can be designed to incorporate fish habitat features, such as deep pools. Introduce fish in consultation with Massachusetts Division of Fisheries and Wildlife. Vegetation within wet basins designed as fish habitat must be properly managed to ensure that vegetation does not overtake the habitat. Proper design to ensure that no low circulation or "dead" zones are created may reduce the potential for mosquito breeding. Introducing bubblers may increase water circulation in the wet basin.

Effective mosquito controls require proponents to design structural BMPs to prevent ponding and facilitate maintenance and, if necessary, the application of larvicides. Examples of such design practices include the following:

- ***Basins:*** Provide perimeter access around wet basins, extended dry detention basins and dry detention basins for both larviciding and routine maintenance. Control vegetation to ensure that access pathways stay open.
- ***BMPs without a permanent pool of water:*** All structural BMPs that do not rely on a permanent pool of water must drain and completely dewater within 72 hours after precipitation. This includes dry detention basins, extended dry detention basins, infiltration basins, and dry water quality swales. Use underdrains at extended dry detention basins to drain the small pools that form due to accumulation of silts. Wallace indicates that extended dry extended detention basins may breed more mosquitoes than wet basins. It is, therefore, imperative to design outlets from extended dry detention basins to completely dewater within the 72-hour period.
- ***Energy Dissipators and Flow Spreaders:*** Currier and Moeller, 2000 indicate that shallow recesses in energy dissipators and flow spreaders trap water where mosquitoes breed. Set the riprap in grout to reduce the shallow recesses and minimize mosquito breeding.
- ***Outlet control structures:*** Debris trapped in small orifices or on trash racks of outlet control structures such as multiple stage outlet risers may clog the orifices or the trash rack, causing a standing pool of water. Optimize the orifice size or trash rack mesh size to provide required peak rate attenuation/water quality detention/retention time while minimizing clogging.
- ***Rain Barrels and Cisterns:*** Seal lids to reduce the likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over inlets. The cistern system should be designed to ensure that all collected water is drained into it within 72 hours.
- ***Subsurface Structures, Deep Sump Catch Basins, Oil Grit Separators, and Leaching Catch Basins:*** Seal all manhole covers to reduce likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over the outlet (CALTRANS 2004).

The Operation and Maintenance Plan should provide for mosquito prevention and control.

- ***Check dams:*** Inspect permanent check dams on the schedule set forth in the O&M Plan. Inspect check dams 72 hours after storms for standing water ponding behind the dam. Take corrective action if standing water is found.
- ***Cisterns:*** Apply *Bs* larvicide in the cistern if any evidence of mosquitoes is found. The Operation and Maintenance Plan shall specify how often larvicides should be applied to waters in the cistern.
- ***Water quality swales:*** Remove and properly dispose of any accumulated sediment as scheduled in the Operation and Maintenance Plan.
- ***Larvicide Treatment:*** The Operation and Maintenance Plan must include measures to minimize mosquito breeding, including larviciding.
- The party identified in the Operation and Maintenance Plan as responsible for maintenance shall see that larvicides are applied as necessary to the following stormwater treatment practices: catch basins, oil/grit separators, wet basins, wet water quality swales, dry extended detention basins, infiltration basins, and constructed stormwater wetlands. The Operation and Maintenance Plan must ensure that all larvicides are applied by a licensed pesticide applicator and in compliance with all pesticide label requirements.
- The Operation and Maintenance Plan should identify the appropriate larvicide and the time and method of application. For example, *Bacillus sphaericus (Bs*), the preferred

larvicide for stormwater BMPs, should be hand-broadcast.[2] Alternatively, Altosid, a Methopren product, may be used. Because some practices are designed to dewater between storms, such as dry extended detention and infiltration basins, the Operation and Maintenance Plan should provide that larviciding must be conducted during or immediately after wet weather, when the detention or infiltration basin has a standing pool of water, unless a product is used that can withstand extended dry periods.

REFERENCES

California Department of Transportation, 2004, BMP Retrofit Pilot Program, Final Report, Report ID CTSW – RT – 1 – 050, http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-01-050.pdf#xml=http://dap1.dot.ca.gov/cgi-bin/texis/webinator/search/pdfhi.txt?query=mosquito&db=db&pr=www&prox=page&rorder=500&rprox=500&rdfreq=500&rwfreq=500&rlead=500&sufs=0&order=r&cq=&id=4673373b7
Appendix E: Vector Monitoring and Abatement, http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/
California Department of Transportation, 2001, Final Vector Report, Caltrans BMP Retrofit Project Sites, Districts 7 and 11, http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-01-050/AppendixE/01_FinalVectorReport.pdf
Currier, Brian, and Moeller, 2000, Glenn, Lessons Learned: The CALTRANS Storm Water Best Management Practice Retrofit Pilot Study, prepared by the California State University Sacramento and University of California Davis for the California Department of Transportation, http://www.owp.csus.edu/research/papers/papers/PP015.pdf
Massachusetts Department of Environmental Protection, 2001, West Nile Virus, Application of Pesticides to Wetland Resource Areas and Buffer Zones and Public Water systems, Guideline No. BRPG01-02, http://www.mass.gov/dep/water/wnvpolcy.doc
O'Meara, G.F., 2003, Mosquitoes Associated With Stormwater Detention/Retention Areas, ENY627, University of Florida, Institute of Food and Agricultural Sciences Extension, http://edis.ifas.ufl.edu/mg338
Taylor, Scott M., and Currier, Brian, 1999, A Wet Pond as a Storm Water Runoff BMP – Case Study, presented at Department of Environmental Resources Engineering, Humboldt State University, Arcata, California http://www.owp.csus.edu/research/papers/papers/PP004.pdf
U.S. EPA, 2005, Stormwater Structures and Mosquitoes, EPA 833-F-05-003, http://www.epa.gov/npdes/pubs/sw_wnv.pdf
U.S. EPA, 2003, Do Stormwater Retention Ponds Contribute to Mosquito Problems, Nonpoint source News-Notes, Issue No. 71, http://notes.tetratech-ffx.com/newsnotes.nsf/0/143f7fa99c3ea25485256d0100618bc9?OpenDocument
Virginia Department of Conservation and Recreation, 2003, Vector Control, Mosquitoes and Stormwater Management, Stormwater Management Technical Bulletin No. 8, http://www.dcr.virginia.gov/soil_&_water/documents/tecbltn8.pdf
Wallace, John R., Stormwater Management and Mosquito Ecology, Stormwater Magazine, March/April 2007, http://www.gradingandexcavation.com/sw_0703_management.html

[2] *Bacillus thuringienis israelensis* or *Bti* is usually applied by helicopter to wetlands and floodplains

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CDS Guide
Operation, Design, Performance and Maintenance

CDS®

Using patented continuous deflective separation technology, the CDS system screens, separates and traps debris, sediment, and oil and grease from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material without blinding. Flow and screening controls physically separate captured solids, and minimize the re-suspension and release of previously trapped pollutants. Inline units can treat up to 6 cfs, and internally bypass flows in excess of 50 cfs (1416 L/s). Available precast or cast-in-place, offline units can treat flows from 1 to 300 cfs (28.3 to 8495 L/s). The pollutant removal capacity of the CDS system has been proven in lab and field testing.

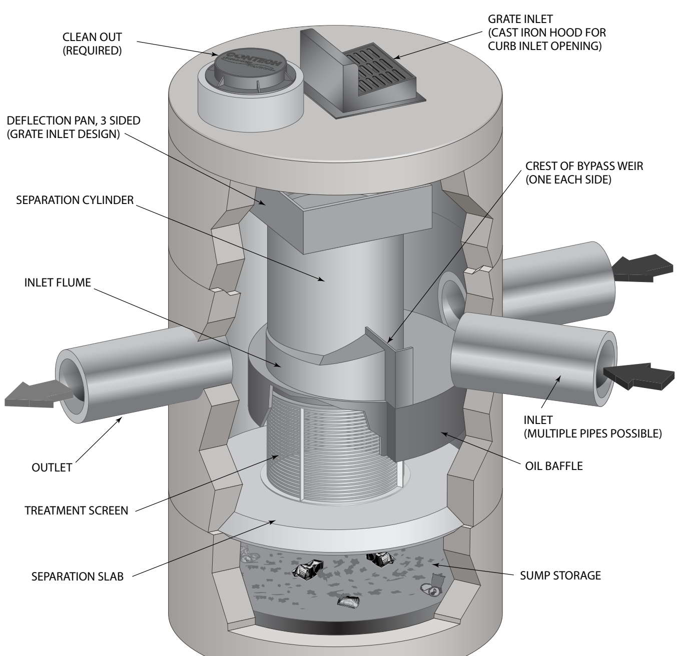
Operation Overview

Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated.

Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped.

Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection.

During the flow events exceeding the treatment design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.



Design Basics

There are three primary methods of sizing a CDS system. The Water Quality Flow Rate Method determines which model size provides the desired removal efficiency at a given flow rate for a defined particle size. The Rational Rainfall Method™ or the and Probabilistic Method is used when a specific removal efficiency of the net annual sediment load is required.

Typically in the Unites States, CDS systems are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size (d50) of 125 microns (μm). For some regulatory environments, CDS systems can also be designed to achieve an 80% annual solids load reduction based on an average particle size (d50) of 75 microns (μm) or 50 microns (μm).

Water Quality Flow Rate Method

In some cases, regulations require that a specific treatment rate, often referred to as the water quality design flow (WQQ), be treated. This WQQ represents the peak flow rate from either an event with a specific recurrence interval, e.g. the six-month storm, or a water quality depth, e.g. 1/2-inch (13 mm) of rainfall.

The CDS is designed to treat all flows up to the WQQ. At influent rates higher than the WQQ, the diversion weir will direct most flow exceeding the WQQ around the separation chamber. This allows removal efficiency to remain relatively constant in the separation chamber and eliminates the risk of washout during bypass flows regardless of influent flow rates.

Treatment flow rates are defined as the rate at which the CDS will remove a specific gradation of sediment at a specific removal efficiency. Therefore the treatment flow rate is variable, based on the gradation and removal efficiency specified by the design engineer.

Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate removal efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes, or hourly, and recorded in 0.01-inch increments. Depths were recorded hourly with 1-mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS system are determined. Performance efficiency curve determined from full scale laboratory tests on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Probabilistic Rational Method

The Probabilistic Rational Method is a sizing program Contech developed to estimate a net annual sediment load reduction for a particular CDS model based on site size, site runoff coefficient, regional rainfall intensity distribution, and anticipated pollutant characteristics.

The Probabilistic Method is an extension of the Rational Method used to estimate peak discharge rates generated by storm events of varying statistical return frequencies (e.g. 2-year storm event). Under the Rational Method, an adjustment factor is used to adjust the runoff coefficient estimated for the 10-year event, correlating a known hydrologic parameter with the target storm event. The rainfall intensities vary depending on the return frequency of the storm event under consideration. In general, these two frequency dependent parameters (rainfall intensity and runoff coefficient) increase as the return frequency increases while the drainage area remains constant.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the Rational Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS are determined. Performance efficiency curve on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Treatment Flow Rate

The inlet throat area is sized to ensure that the WQQ passes through the separation chamber at a water surface elevation equal to the crest of the diversion weir. The diversion weir bypasses excessive flows around the separation chamber, thus preventing re-suspension or re-entrainment of previously captured particles.

Hydraulic Capacity

The hydraulic capacity of a CDS system is determined by the length and height of the diversion weir and by the maximum allowable head in the system. Typical configurations allow hydraulic capacities of up to ten times the treatment flow rate. The crest of the diversion weir may be lowered and the inlet throat may be widened to increase the capacity of the system at a given water surface elevation. The unit is designed to meet project specific hydraulic requirements.

Performance

Full-Scale Laboratory Test Results

A full-scale CDS system (Model CDS2020-5B) was tested at the facility of University of Florida, Gainesville, FL. This CDS unit was evaluated under controlled laboratory conditions of influent flow rate and addition of sediment.

Two different gradations of silica sand material (UF Sediment & OK-110) were used in the CDS performance evaluation. The particle size distributions (PSDs) of the test materials were analyzed using standard method "Gradation ASTM D-422 "Standard Test Method for Particle-Size Analysis of Soils" by a certified laboratory.

UF Sediment is a mixture of three different products produced by the U.S. Silica Company: "Sil-Co-Sil 106", "#1 DRY" and "20/40 Oil Frac". Particle size distribution analysis shows that the UF Sediment has a very fine gradation (d50 = 20 to 30 μm) covering a wide size range (Coefficient of Uniformity, C averaged at 10.6). In comparison with the hypothetical TSS gradation specified in the NJDEP (New Jersey Department of Environmental Protection) and NJCAT (New Jersey Corporation for Advanced Technology) protocol for lab testing, the UF Sediment covers a similar range of particle size but with a finer d50 (d50 for NJDEP is approximately 50 μm) (NJDEP, 2003).

The OK-110 silica sand is a commercial product of U.S. Silica Sand. The particle size distribution analysis of this material, also included in Figure 1, shows that 99.9% of the OK-110 sand is finer than 250 microns, with a mean particle size (d50) of 106 microns. The PSDs for the test material are shown in Figure 1.

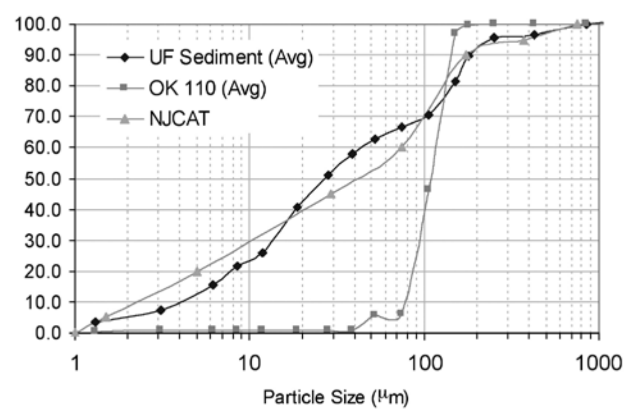


Figure 1. Particle size distributions

Tests were conducted to quantify the performance of a specific CDS unit (1.1 cfs (31.3-L/s) design capacity) at various flow rates, ranging from 1% up to 125% of the treatment design capacity of the unit, using the 2400 micron screen. All tests were conducted with controlled influent concentrations of approximately 200 mg/L. Effluent samples were taken at equal time intervals across the entire duration of each test run. These samples were then processed with a Dekaport Cone sample splitter to obtain representative sub-samples for Suspended Sediment Concentration (SSC) testing using ASTM D3977-97 "Standard Test Methods for Determining Sediment Concentration in Water Samples", and particle size distribution analysis.

Results and Modeling

Based on the data from the University of Florida, a performance model was developed for the CDS system. A regression analysis was used to develop a fitting curve representative of the scattered data points at various design flow rates. This model, which demonstrated good agreement with the laboratory data, can then be used to predict CDS system performance with respect to SSC removal for any particle size gradation, assuming the particles are inorganic sandy-silt. Figure 2 shows CDS predictive performance for two typical particle size gradations (NJCAT gradation and OK-110 sand) as a function of operating rate.

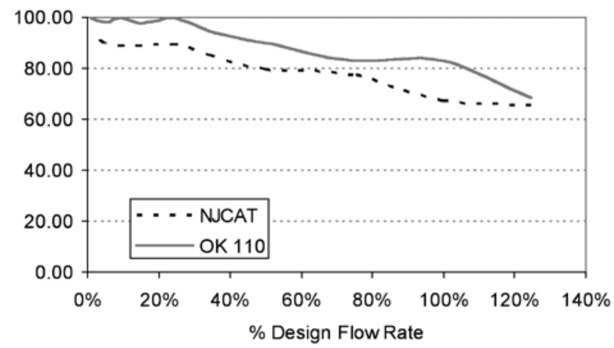


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

Many regulatory jurisdictions set a performance standard for hydrodynamic devices by stating that the devices shall be capable of achieving an 80% removal efficiency for particles having a mean particle size (d50) of 125 microns (e.g. Washington State Department of Ecology — WASDOE - 2008). The model can be used to calculate the expected performance of such a PSD (shown in Figure 3). The model indicates (Figure 4) that the CDS system with 2400 micron screen achieves approximately 80% removal at the design (100%) flow rate, for this particle size distribution (d50 = 125 μm).

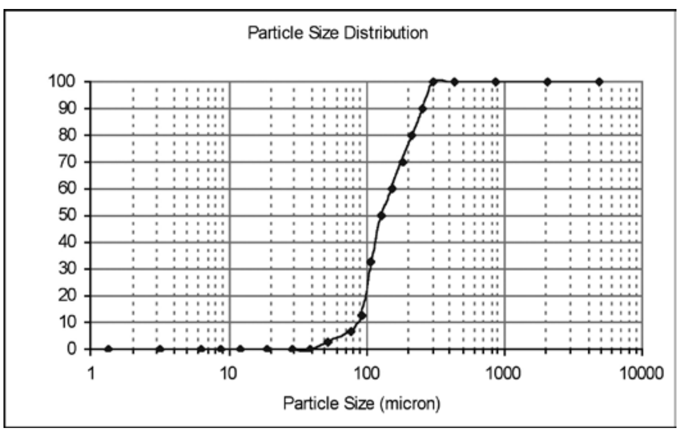


Figure 3. WASDOE PSD

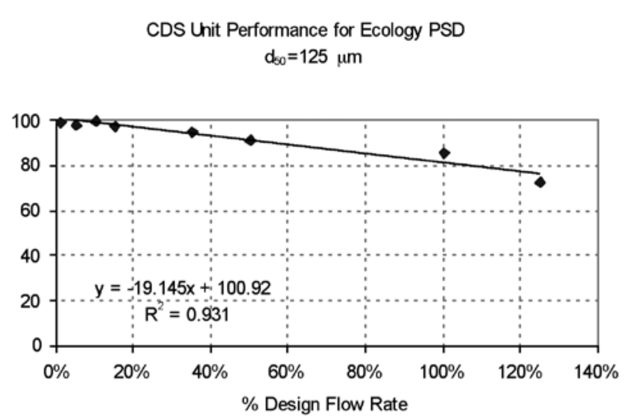


Figure 4. Modeled performance for WASDOE PSD.

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example, unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (e.g. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified

during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained outside the screen. For deep units, a single manhole access point would allows both sump cleanout and access outside the screen.

The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. If absorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Particles at the top of the pile typically offer less resistance to the end of the rod than consolidated particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine weather the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of a CDS systems should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be cleaned out if pollutant build-up exists in this area.

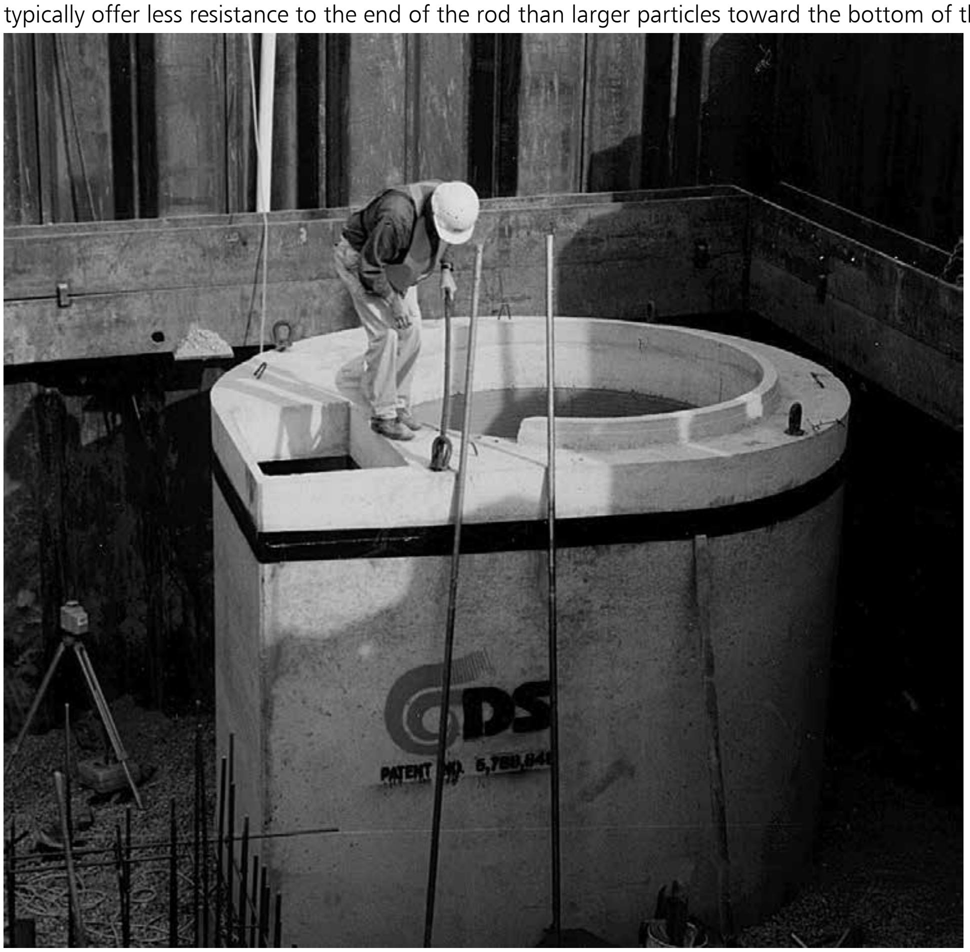
In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. The screen should be cleaned to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure that proper safety precautions have been followed. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many jurisdictions, disposal of the sediments may be handled in the same manner as the disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

CDS Model	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	y^3	m^3
CDS1515	3	0.9	3.0	0.9	0.5	0.4
CDS2015	4	1.2	3.0	0.9	0.9	0.7
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3025	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3
CDS5640	10	3.0	6.3	1.9	8.7	6.7
CDS5653	10	3.0	7.7	2.3	8.7	6.7
CDS5668	10	3.0	9.3	2.8	8.7	6.7
CDS5678	10	3.0	10.3	3.1	8.7	6.7

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Note: To avoid underestimating the volume of sediment in the chamber, carefully lower the measuring device to the top of the sediment pile. Finer silty particles at the top of the pile may be more difficult to feel with a measuring stick. These finer particles typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.



CDS Inspection & Maintenance Log

CDS Model: ______________________ Location: ______________________

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than the values listed in table 1 the system should be cleaned out. **Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile**.

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

SUPPORT

- Drawings and specifications are available at www.ContechES.com.
- Site-specific design support is available from our engineers.

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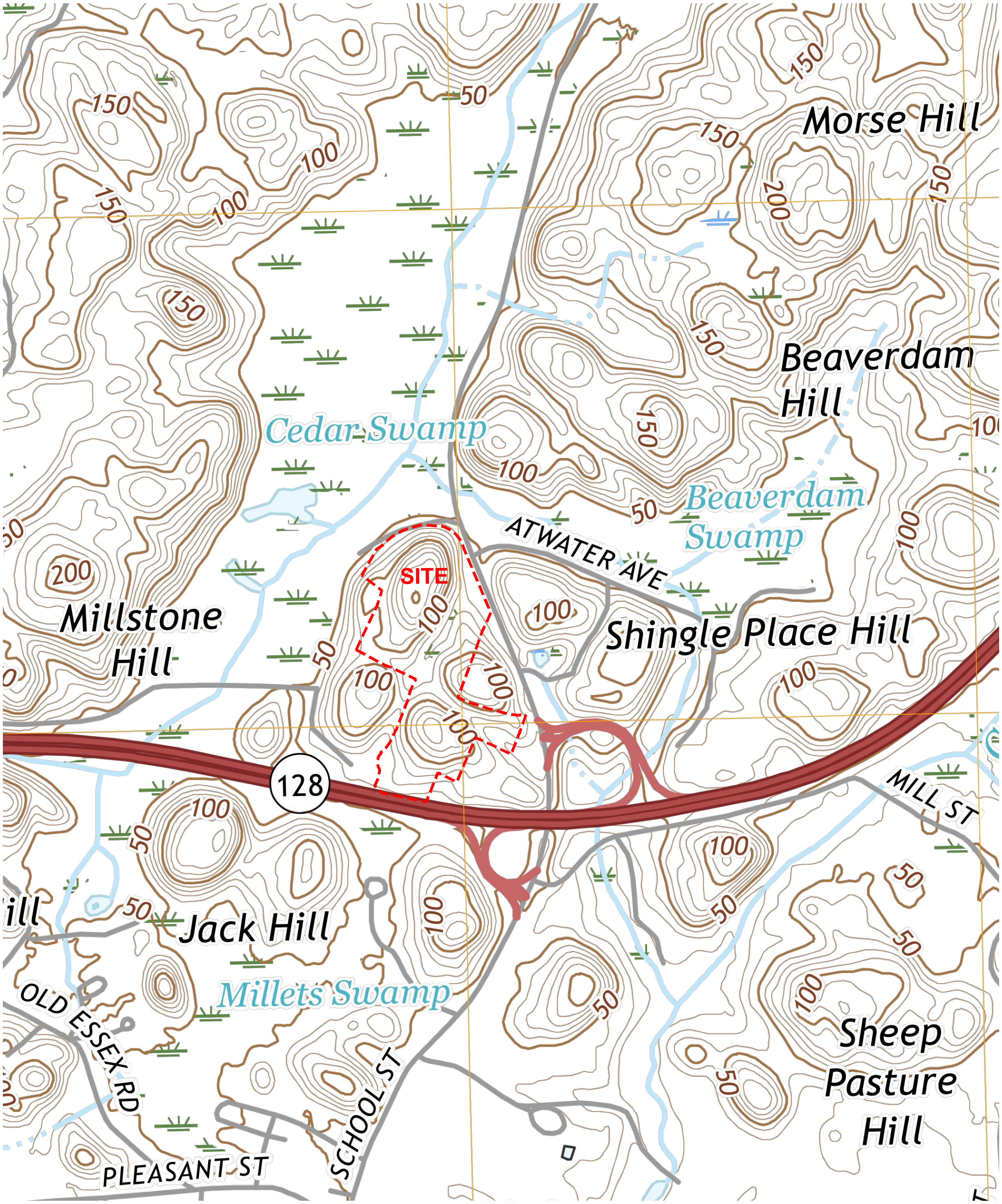
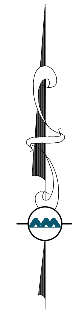
cds_manual 3/17 PDF

SECTION 3.0 - EXHIBITS





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PROJECT:
MULTI-FAMILY DEVELOPMENT
339 BOSTON POST ROAD EAST
MARLBOROUGH, MA

USGS SITE LOCUS MAP

PROJECT NO.	2725-01	DATE:	07/16/2021
SCALE:	1"=500'	DWG. NAME:	EXHIBIT
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-1

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MULTI-FAMILY DEVELOPMENT
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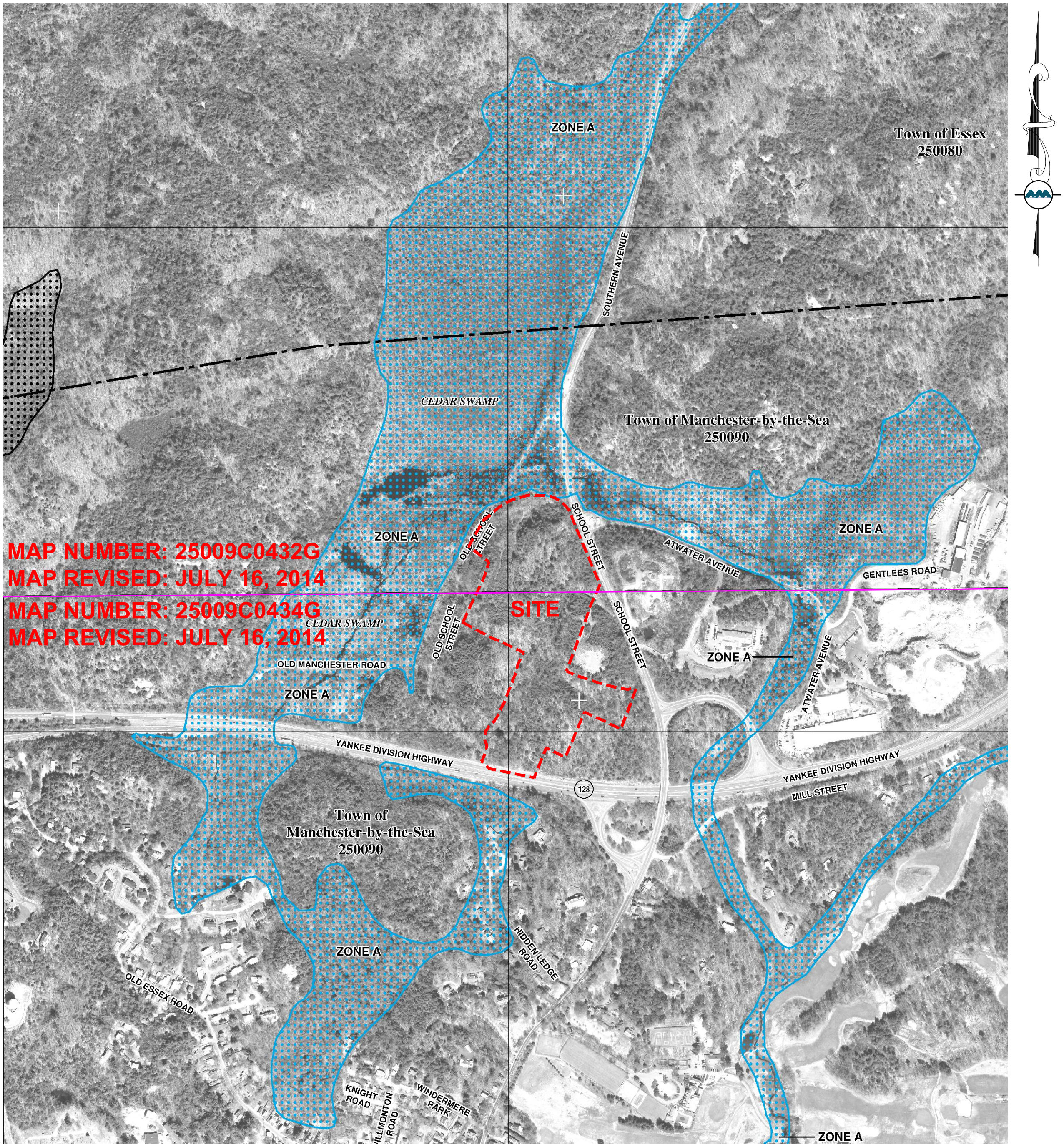
MARLBOROUGH, MA

AERIAL PHOTO

PROJECT NO.	2725-01	DATE:	07/16/2021
SCALE:	1"=300'	DWG. NAME:	EXHIBIT
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-2



FEMA FLOOD INSURANCE RATE MAP
MIDDLESEX COUNTY, MASSACHUSETTS
MAP NUMBERS: 25009C0432G & 25009C0434G
JULY 16, 2014

PREPARED BY:

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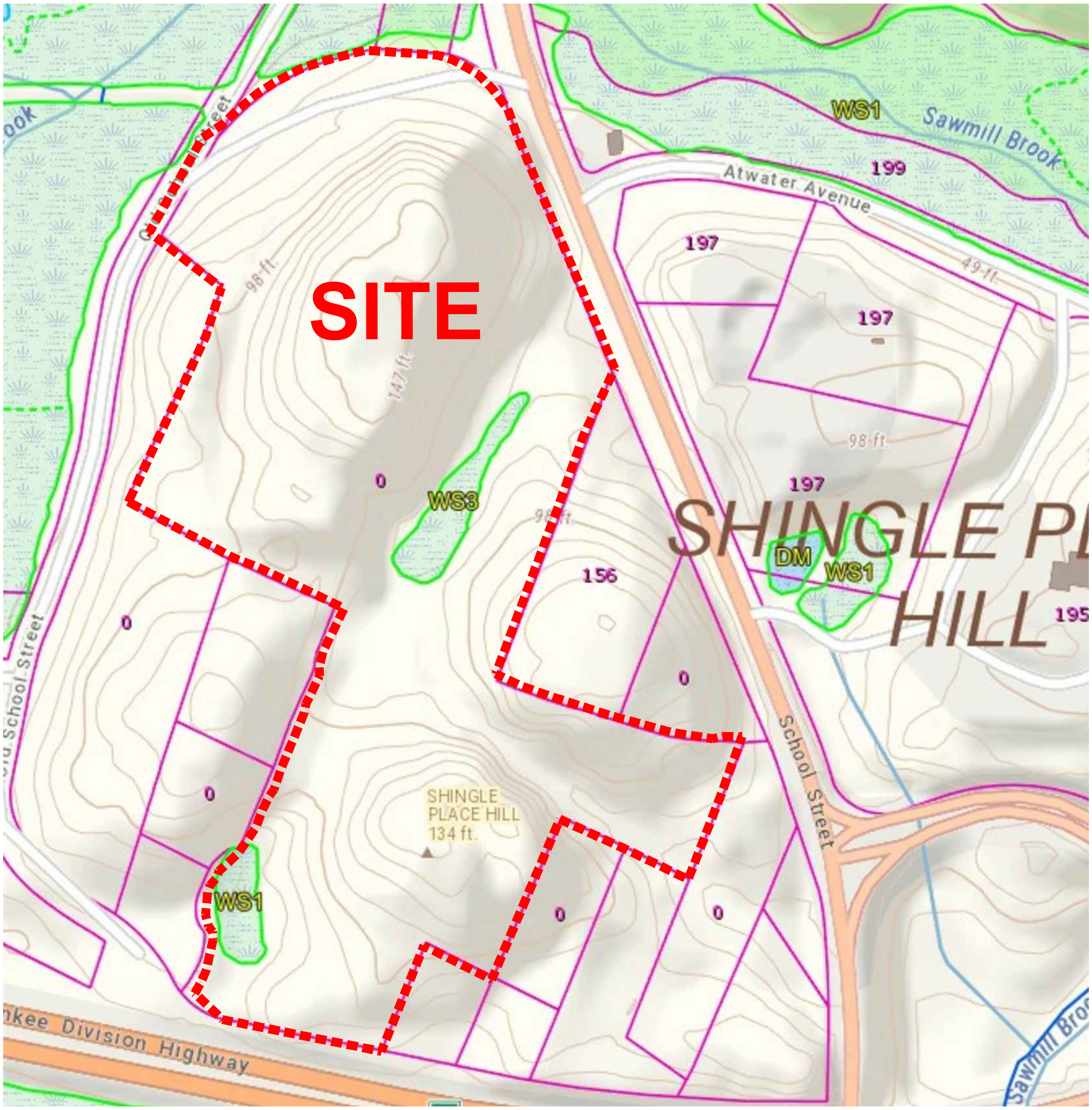
FEMA FIRM MAP

PROJECT NO.	2725-01	DATE:	07/16/2021
SCALE:	1"=300'	DWG. NAME:	EXHIBIT
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-3



LEGEND

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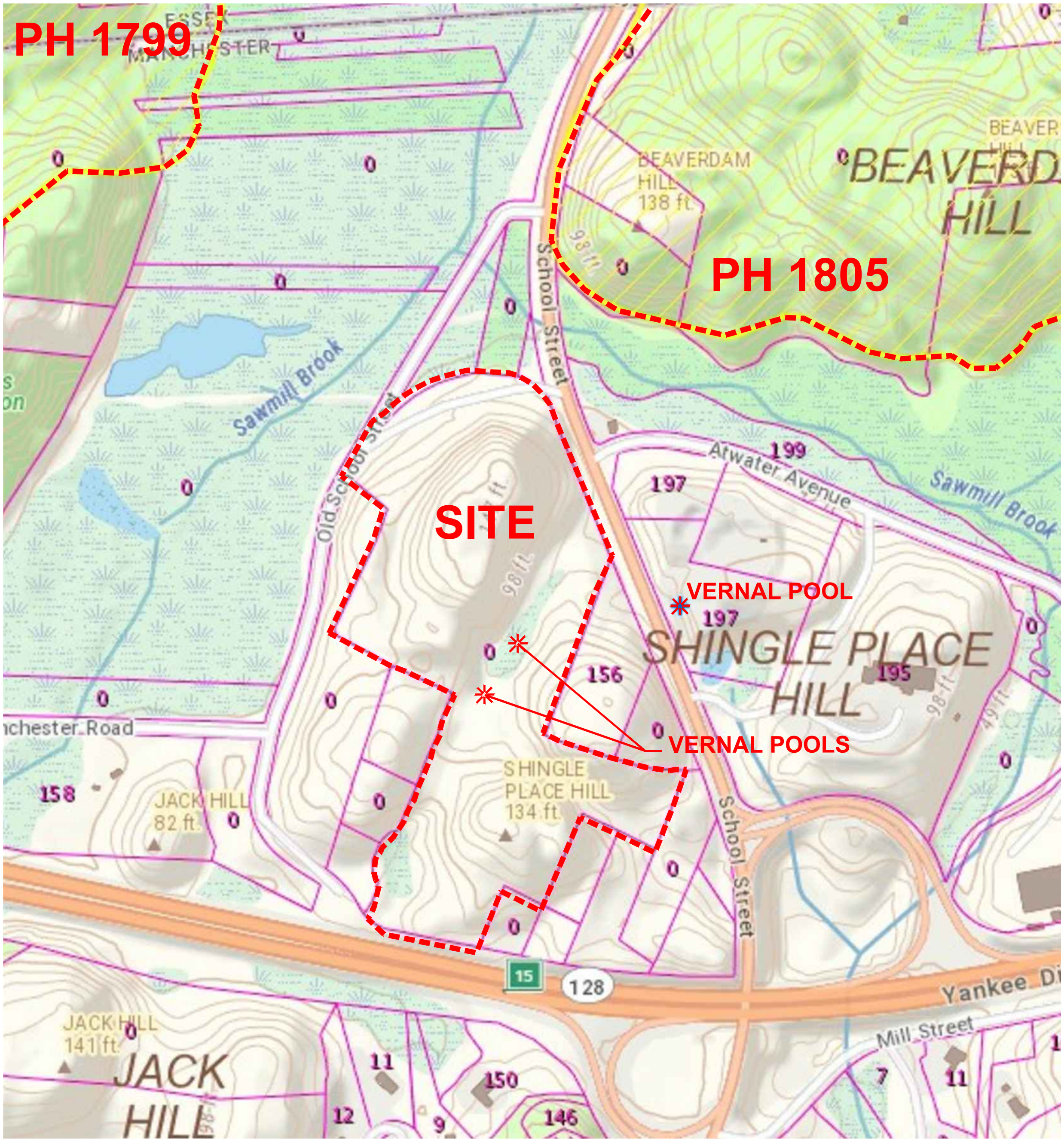
MARLBOROUGH, MA

MASS DEP WETLANDS & VERNAL POOLS

PROJECT NO.	2725-01	DATE:	07/16/2021
SCALE:	1"=500'	DWG. NAME:	EXHIBIT
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-4



NO NHESP PRIORITY HABITATS ON-SITE.

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NHESP PRIORITY HABITATS

PROJECT NO.	2725-01	DATE:	07/16/2021
SCALE:	1"=500'	DWG. NAME:	EXHIBIT
DESIGNED BY:	SJL	CHECKED BY:	CMQ

SHEET No.
EX-5

SECTION 4.0 – HYDRO CAD

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
9,028	91	Gravel roads, HSG D (E-1, E-3, E-5)
8,184	77	Wetlands, Good, HSG D (E-5)
488,904	77	Woods, Good, HSG D (E-1, E-2, E-3, E-4, E-5)
506,116	77	TOTAL AREA

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
0	HSG C	
506,116	HSG D	E-1, E-2, E-3, E-4, E-5
0	Other	
506,116		TOTAL AREA

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Subcatchment Numbers
0	0	0	9,028	0	9,028	Gravel roads	E-1, E-3, E-5
0	0	0	8,184	0	8,184	Wetlands, Good	E-5
0	0	0	488,904	0	488,904	Woods, Good	E-1, E-2, E-3, E-4, E-5
0	0	0	506,116	0	506,116	TOTAL AREA	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	SP-4	46.64	46.38	82.0	0.0032	0.012	12.0	0.0	0.0

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D" — Runoff Area=174,469 sf 0.00% Impervious Runoff Depth=1.24"
Flow Length=411' Tc=12.5 min CN=77 Runoff=4.52 cfs 18,035 cf

Subcatchment E-2: Flow West to Wetlands "F" — Runoff Area=31,627 sf 0.00% Impervious Runoff Depth=1.24"
Flow Length=203' Tc=10.9 min CN=77 Runoff=0.86 cfs 3,269 cf

Subcatchment E-3: Flow Southwest Off-Site — Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=1.30"
Tc=6.0 min CN=78 Runoff=0.94 cfs 3,013 cf

Subcatchment E-4: Flow Southeast to Wetlands "A" — Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=1.24"
Flow Length=300' Tc=20.2 min CN=77 Runoff=4.02 cfs 19,162 cf

Subcatchment E-5: Off-Site Runoff NorthEast — Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=1.30"
Flow Length=299' Tc=9.8 min CN=78 Runoff=2.59 cfs 9,434 cf

Pond 1P: On-Site Depression — Peak Elev=95.08' Storage=8,931 cf Inflow=2.59 cfs 9,434 cf
Discarded=0.01 cfs 755 cf Primary=0.00 cfs 0 cf Outflow=0.01 cfs 755 cf

Pond SP-4: Study Point #4 — Peak Elev=48.35' Storage=1,041 cf Inflow=4.02 cfs 19,162 cf
12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=3.23 cfs 19,162 cf

Link SP-1: Study Point #1 — Inflow=4.52 cfs 18,035 cf
Primary=4.52 cfs 18,035 cf

Link SP-2: Study Point #2 — Inflow=0.86 cfs 3,269 cf
Primary=0.86 cfs 3,269 cf

Link SP-3: Study Point #3 — Inflow=0.94 cfs 3,013 cf
Primary=0.94 cfs 3,013 cf

Total Runoff Area = 506,116 sf Runoff Volume = 52,913 cf Average Runoff Depth = 1.25"
100.00% Pervious = 506,116 sf 0.00% Impervious = 0 sf

Summary for Subcatchment E-1: Flow North to Wetland "D"

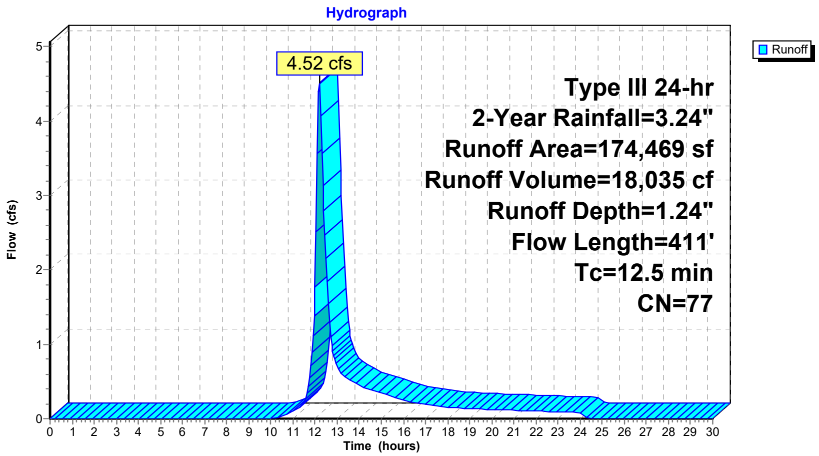
Runoff = 4.52 cfs @ 12.18 hrs, Volume= 18,035 cf, Depth= 1.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
169,906	77	Woods, Good, HSG D
174,469	77	Weighted Average
174,469		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.7	361	0.2627	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.5	411	Total			

Subcatchment E-1: Flow North to Wetland "D"



Summary for Subcatchment E-2: Flow West to Wetlands "F"

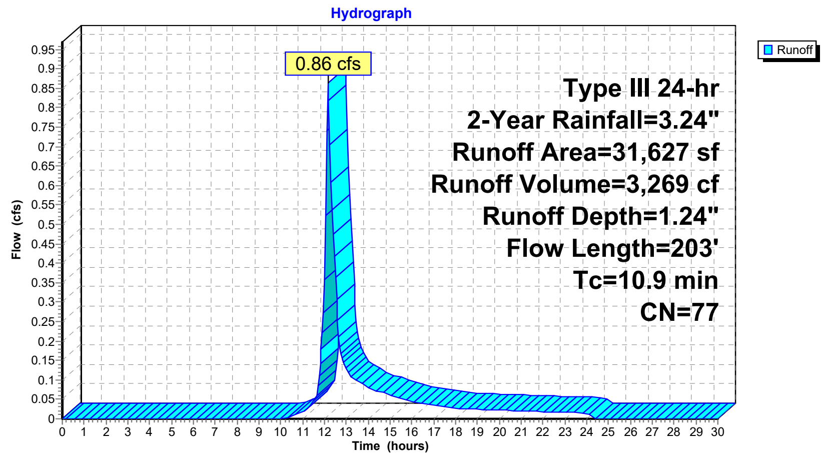
Runoff = 0.86 cfs @ 12.16 hrs, Volume= 3,269 cf, Depth= 1.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
31,627	77	Woods, Good, HSG D
31,627		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9	50	0.1836	0.09		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.0	153	0.2729	1.31		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
10.9	203	Total			

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

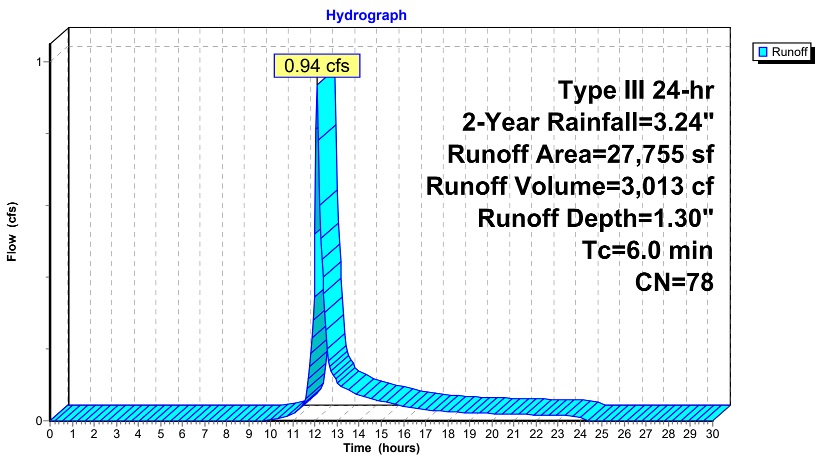
Runoff = 0.94 cfs @ 12.10 hrs, Volume= 3,013 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

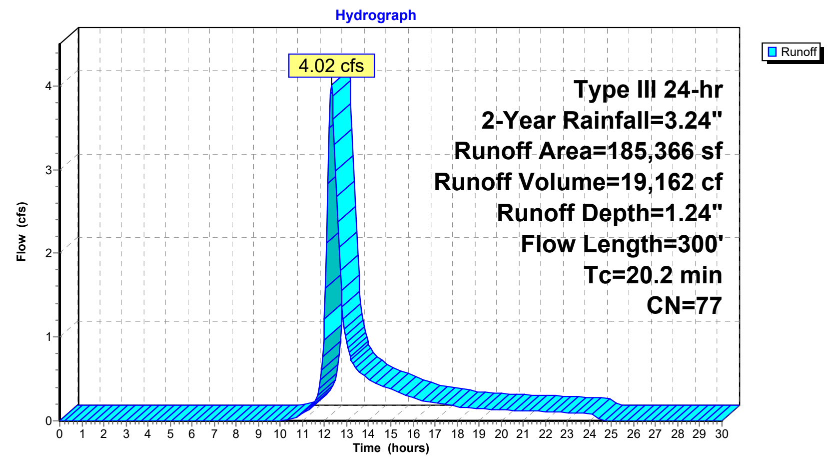
Runoff = 4.02 cfs @ 12.30 hrs, Volume= 19,162 cf, Depth= 1.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

Subcatchment E-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment E-5: Off-Site Runoff NorthEast

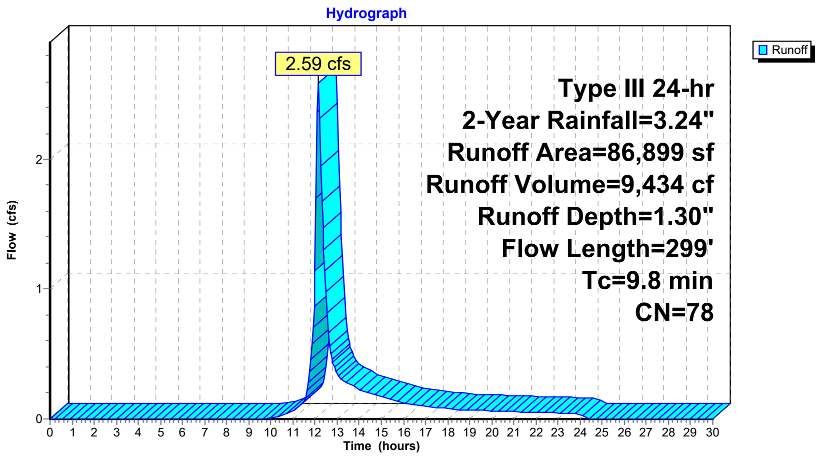
Runoff = 2.59 cfs @ 12.15 hrs, Volume= 9,434 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

	Area (sf)	CN	Description
	3,378	91	Gravel roads, HSG D
	75,337	77	Woods, Good, HSG D
*	8,184	77	Wetlands, Good, HSG D
	86,899	78	Weighted Average
	86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

Subcatchment E-5: Off-Site Runoff NorthEast



Summary for Pond 1P: On-Site Depression

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 1.30" for 2-Year event
Inflow = 2.59 cfs @ 12.15 hrs, Volume= 9,434 cf
Outflow = 0.01 cfs @ 24.18 hrs, Volume= 755 cf, Atten= 100%, Lag= 722.0 min
Discarded = 0.01 cfs @ 24.18 hrs, Volume= 755 cf
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 95.08' @ 24.18 hrs Surf.Area= 5,886 sf Storage= 8,931 cf

Plug-Flow detention time= 586.7 min calculated for 754 cf (8% of inflow)
Center-of-Mass det. time= 425.2 min (1,277.2 - 852.0)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)

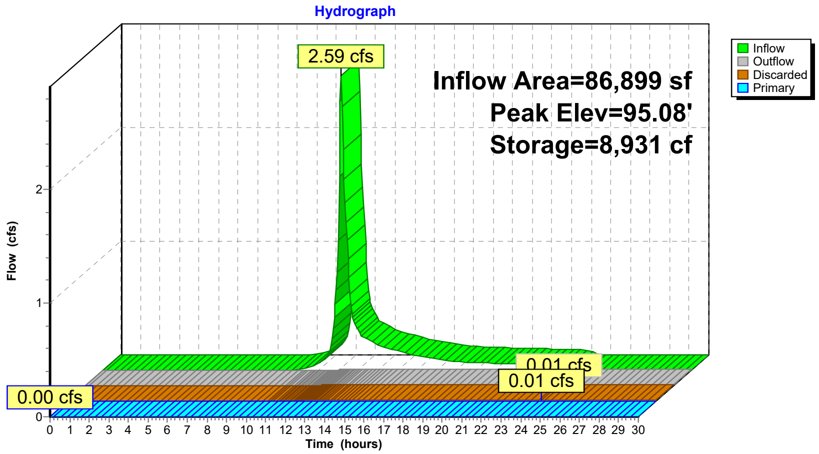
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.01 cfs @ 24.18 hrs HW=95.08' (Free Discharge)
└1=Exfiltration (D Soil) (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)
└2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 1P: On-Site Depression



Summary for Pond SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 1.24" for 2-Year event
Inflow = 4.02 cfs @ 12.30 hrs, Volume= 19,162 cf
Outflow = 3.23 cfs @ 12.46 hrs, Volume= 19,162 cf, Atten= 20%, Lag= 9.9 min
Primary = 3.23 cfs @ 12.46 hrs, Volume= 19,162 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 48.35' @ 12.46 hrs Surf.Area= 2,634 sf Storage= 1,041 cf

Plug-Flow detention time= 1.7 min calculated for 19,130 cf (100% of inflow)
Center-of-Mass det. time= 1.7 min (866.5 - 864.8)

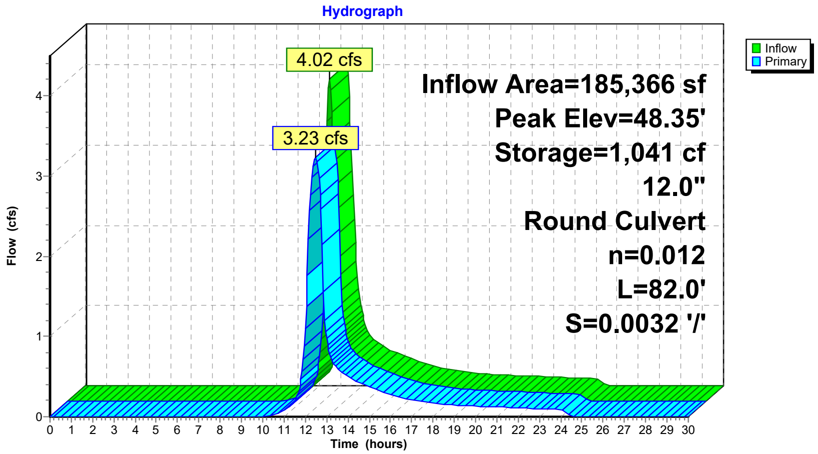
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	12.0" Round Culvert L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=3.22 cfs @ 12.46 hrs HW=48.35' (Free Discharge)
└─1=Culvert (Barrel Controls 3.22 cfs @ 4.10 fps)

Pond SP-4: Study Point #4

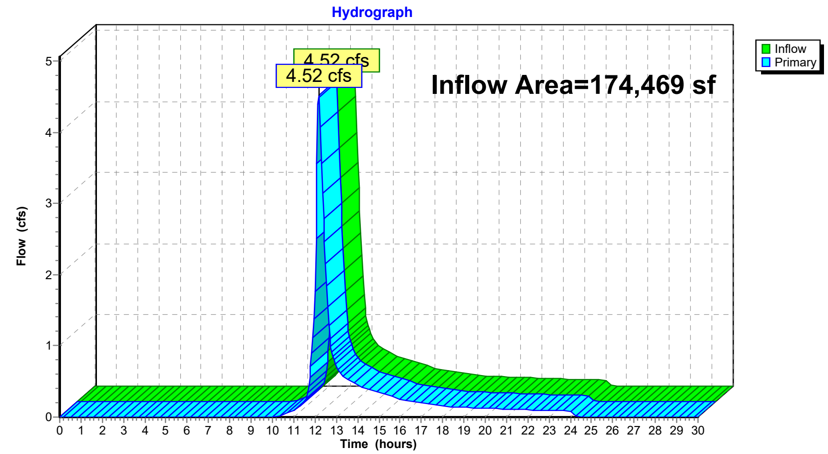


Summary for Link SP-1: Study Point #1

Inflow Area =	174,469 sf, 0.00% Impervious,	Inflow Depth = 1.24"	for 2-Year event
Inflow =	4.52 cfs @ 12.18 hrs, Volume=	18,035 cf	
Primary =	4.52 cfs @ 12.18 hrs, Volume=	18,035 cf, Atten= 0%, Lag= 0.0 min	

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

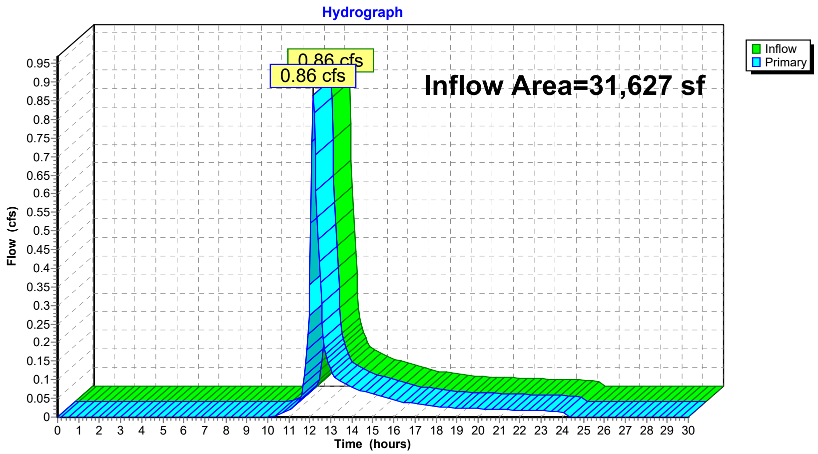


Summary for Link SP-2: Study Point #2

Inflow Area = 31,627 sf, 0.00% Impervious, Inflow Depth = 1.24" for 2-Year event
Inflow = 0.86 cfs @ 12.16 hrs, Volume= 3,269 cf
Primary = 0.86 cfs @ 12.16 hrs, Volume= 3,269 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

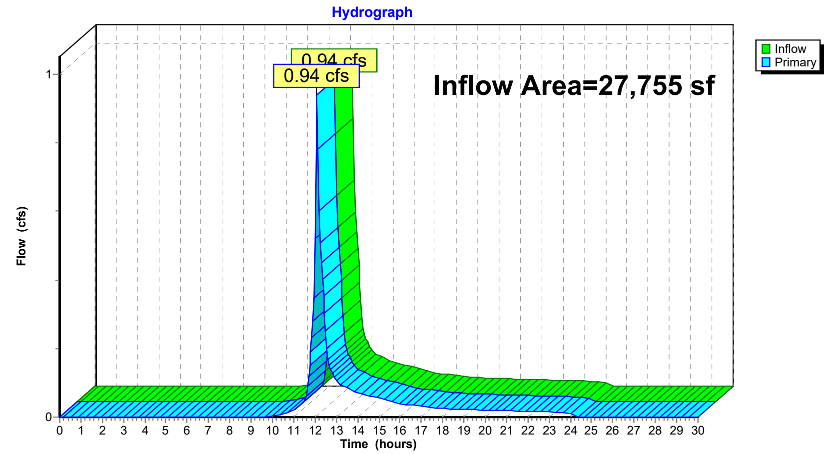


Summary for Link SP-3: Study Point #3

Inflow Area = 27,755 sf, 0.00% Impervious, Inflow Depth = 1.30" for 2-Year event
Inflow = 0.94 cfs @ 12.10 hrs, Volume= 3,013 cf
Primary = 0.94 cfs @ 12.10 hrs, Volume= 3,013 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D"	Runoff Area=174,469 sf 0.00% Impervious Runoff Depth=2.52" Flow Length=411' Tc=12.5 min CN=77 Runoff=9.46 cfs 36,681 cf
Subcatchment E-2: Flow West to Wetlands "F"	Runoff Area=31,627 sf 0.00% Impervious Runoff Depth=2.52" Flow Length=203' Tc=10.9 min CN=77 Runoff=1.81 cfs 6,649 cf
Subcatchment E-3: Flow Southwest Off-Site	Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=2.61" Tc=6.0 min CN=78 Runoff=1.91 cfs 6,037 cf
Subcatchment E-4: Flow Southeast to Wetlands "A"	Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=2.52" Flow Length=300' Tc=20.2 min CN=77 Runoff=8.40 cfs 38,972 cf
Subcatchment E-5: Off-Site Runoff NorthEast	Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=2.61" Flow Length=299' Tc=9.8 min CN=78 Runoff=5.30 cfs 18,901 cf
Pond 1P: On-Site Depression	Peak Elev=96.42' Storage=18,188 cf Inflow=5.30 cfs 18,901 cf Discarded=0.02 cfs 1,056 cf Primary=0.00 cfs 0 cf Outflow=0.02 cfs 1,056 cf
Pond SP-4: Study Point #4	Peak Elev=49.18' Storage=5,856 cf Inflow=8.40 cfs 38,972 cf 12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=4.41 cfs 38,972 cf
Link SP-1: Study Point #1	Inflow=9.46 cfs 36,681 cf Primary=9.46 cfs 36,681 cf
Link SP-2: Study Point #2	Inflow=1.81 cfs 6,649 cf Primary=1.81 cfs 6,649 cf
Link SP-3: Study Point #3	Inflow=1.91 cfs 6,037 cf Primary=1.91 cfs 6,037 cf

Total Runoff Area = 506,116 sf Runoff Volume = 107,241 cf Average Runoff Depth = 2.54"
100.00% Pervious = 506,116 sf 0.00% Impervious = 0 sf

Summary for Subcatchment E-1: Flow North to Wetland "D"

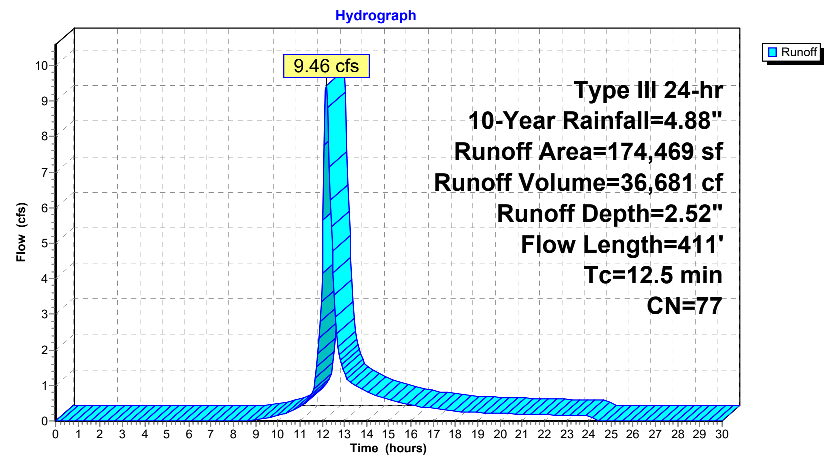
Runoff = 9.46 cfs @ 12.18 hrs, Volume= 36,681 cf, Depth= 2.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
169,906	77	Woods, Good, HSG D
174,469	77	Weighted Average
174,469		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.7	361	0.2627	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.5	411	Total			

Subcatchment E-1: Flow North to Wetland "D"



Summary for Subcatchment E-2: Flow West to Wetlands "F"

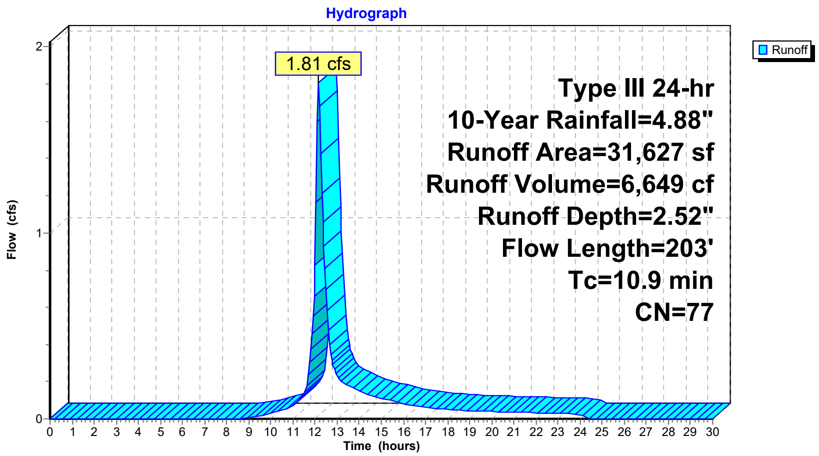
Runoff = 1.81 cfs @ 12.16 hrs, Volume= 6,649 cf, Depth= 2.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
31,627	77	Woods, Good, HSG D
31,627		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9	50	0.1836	0.09		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.0	153	0.2729	1.31		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
10.9	203	Total			

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

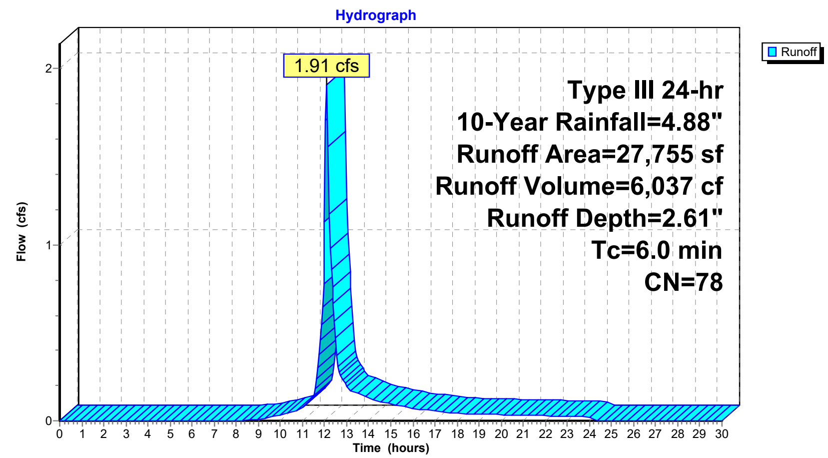
Runoff = 1.91 cfs @ 12.09 hrs, Volume= 6,037 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

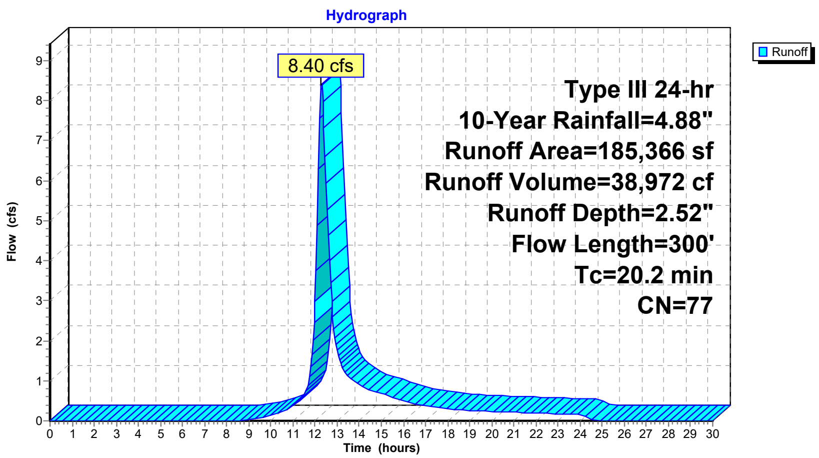
Runoff = 8.40 cfs @ 12.28 hrs, Volume= 38,972 cf, Depth= 2.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

Subcatchment E-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment E-5: Off-Site Runoff NorthEast

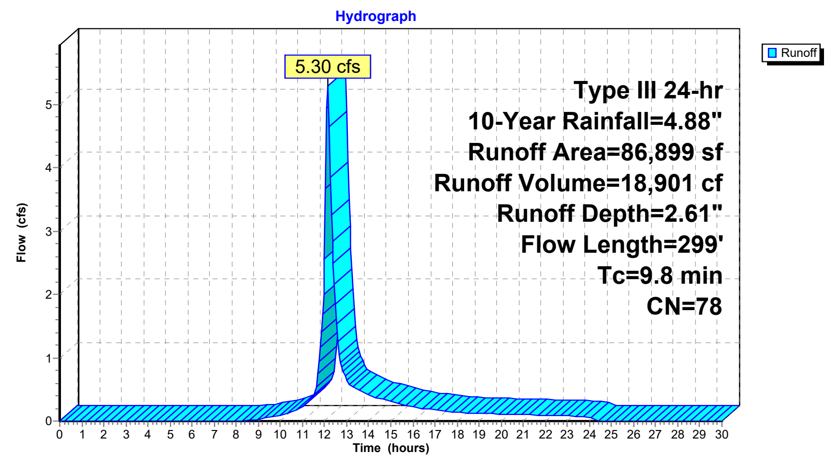
Runoff = 5.30 cfs @ 12.14 hrs, Volume= 18,901 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

	Area (sf)	CN	Description
	3,378	91	Gravel roads, HSG D
	75,337	77	Woods, Good, HSG D
*	8,184	77	Wetlands, Good, HSG D
	86,899	78	Weighted Average
	86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

Subcatchment E-5: Off-Site Runoff NorthEast



Summary for Pond 1P: On-Site Depression

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 2.61" for 10-Year event
Inflow = 5.30 cfs @ 12.14 hrs, Volume= 18,901 cf
Outflow = 0.02 cfs @ 24.20 hrs, Volume= 1,056 cf, Atten= 100%, Lag= 723.4 min
Discarded = 0.02 cfs @ 24.20 hrs, Volume= 1,056 cf
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 96.42' @ 24.20 hrs Surf.Area= 7,980 sf Storage= 18,188 cf

Plug-Flow detention time= 631.2 min calculated for 1,056 cf (6% of inflow)
Center-of-Mass det. time= 428.3 min (1,260.0 - 831.7)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)

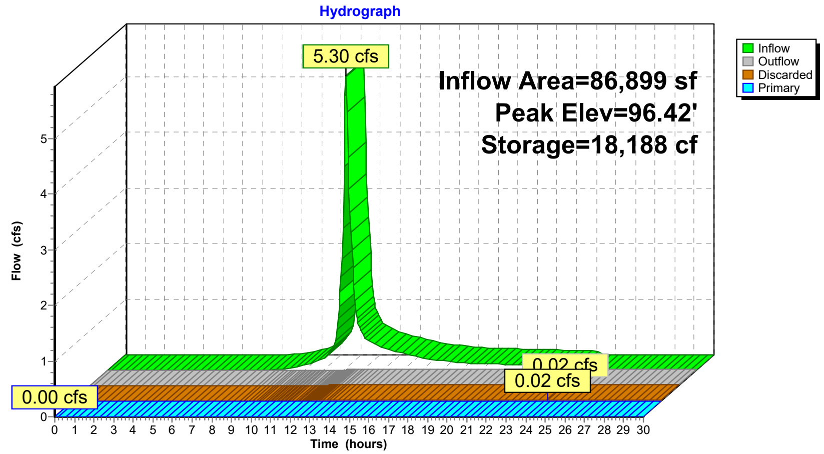
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.02 cfs @ 24.20 hrs HW=96.42' (Free Discharge)
└1=Exfiltration (D Soil) (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)
└2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 1P: On-Site Depression



Summary for Pond SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 2.52" for 10-Year event
Inflow = 8.40 cfs @ 12.28 hrs, Volume= 38,972 cf
Outflow = 4.41 cfs @ 12.62 hrs, Volume= 38,972 cf, Atten= 48%, Lag= 20.1 min
Primary = 4.41 cfs @ 12.62 hrs, Volume= 38,972 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 49.18' @ 12.62 hrs Surf.Area= 8,589 sf Storage= 5,856 cf

Plug-Flow detention time= 7.6 min calculated for 38,907 cf (100% of inflow)
Center-of-Mass det. time= 7.6 min (851.6 - 844.0)

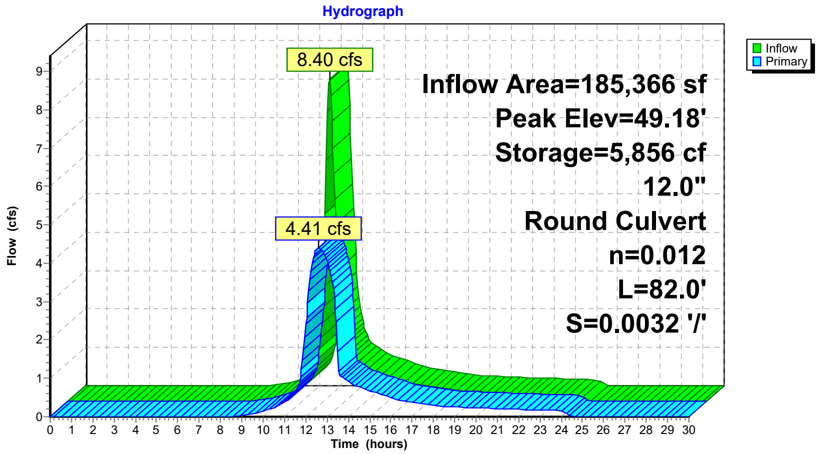
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	12.0" Round Culvert L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=4.40 cfs @ 12.62 hrs HW=49.18' (Free Discharge)
└─1=Culvert (Barrel Controls 4.40 cfs @ 5.61 fps)

Pond SP-4: Study Point #4

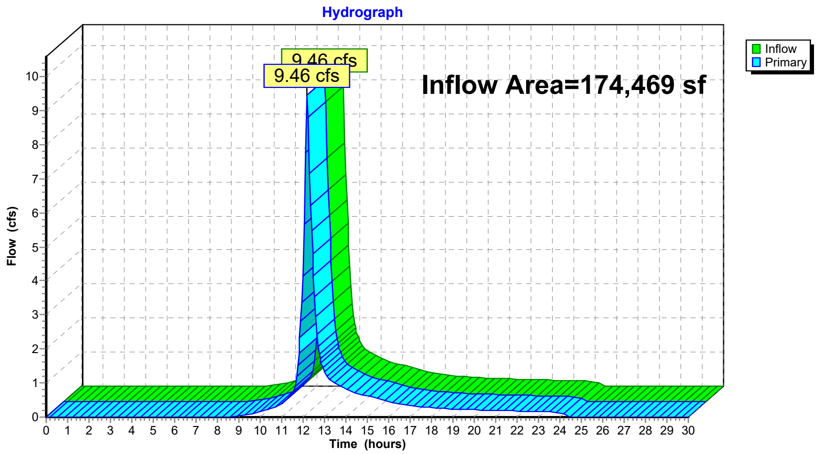


Summary for Link SP-1: Study Point #1

Inflow Area = 174,469 sf, 0.00% Impervious, Inflow Depth = 2.52" for 10-Year event
Inflow = 9.46 cfs @ 12.18 hrs, Volume= 36,681 cf
Primary = 9.46 cfs @ 12.18 hrs, Volume= 36,681 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

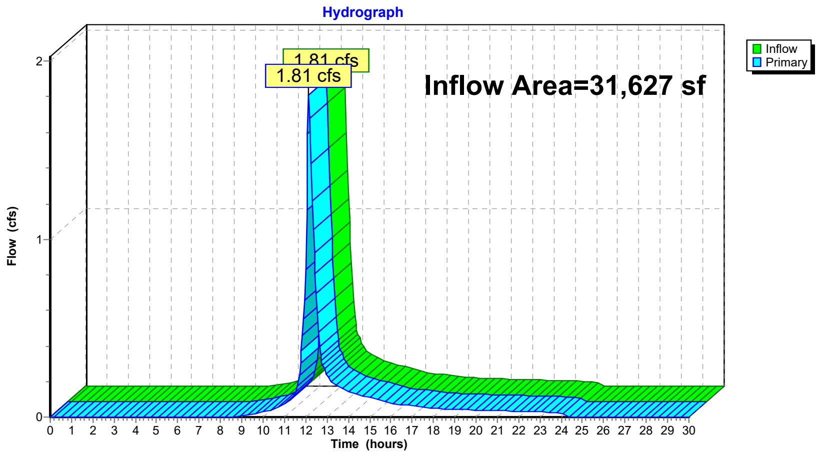


Summary for Link SP-2: Study Point #2

Inflow Area = 31,627 sf, 0.00% Impervious, Inflow Depth = 2.52" for 10-Year event
Inflow = 1.81 cfs @ 12.16 hrs, Volume= 6,649 cf
Primary = 1.81 cfs @ 12.16 hrs, Volume= 6,649 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

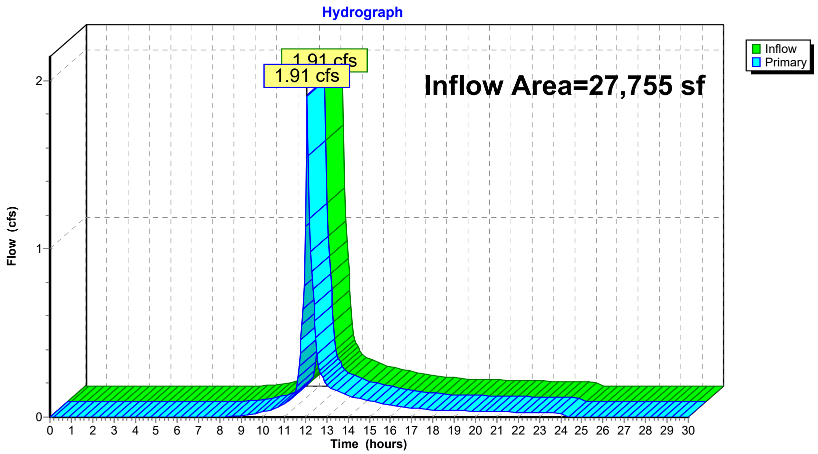


Summary for Link SP-3: Study Point #3

Inflow Area =	27,755 sf, 0.00% Impervious, Inflow Depth = 2.61" for 10-Year event	
Inflow =	1.91 cfs @ 12.09 hrs, Volume=	6,037 cf
Primary =	1.91 cfs @ 12.09 hrs, Volume=	6,037 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D"	Runoff Area=174,469 sf 0.00% Impervious Runoff Depth=3.63" Flow Length=411' Tc=12.5 min CN=77 Runoff=13.70 cfs 52,747 cf
Subcatchment E-2: Flow West to Wetlands "F"	Runoff Area=31,627 sf 0.00% Impervious Runoff Depth=3.63" Flow Length=203' Tc=10.9 min CN=77 Runoff=2.60 cfs 9,562 cf
Subcatchment E-3: Flow Southwest Off-Site	Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=3.73" Tc=6.0 min CN=78 Runoff=2.72 cfs 8,626 cf
Subcatchment E-4: Flow Southeast to Wetlands "A"	Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=3.63" Flow Length=300' Tc=20.2 min CN=77 Runoff=12.10 cfs 56,042 cf
Subcatchment E-5: Off-Site Runoff NorthEast	Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=3.73" Flow Length=299' Tc=9.8 min CN=78 Runoff=7.56 cfs 27,007 cf
Pond 1P: On-Site Depression	Peak Elev=97.33' Storage=26,139 cf Inflow=7.56 cfs 27,007 cf Discarded=0.02 cfs 1,277 cf Primary=0.00 cfs 0 cf Outflow=0.02 cfs 1,277 cf
Pond SP-4: Study Point #4	Peak Elev=49.76' Storage=11,384 cf Inflow=12.10 cfs 56,042 cf 12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=5.06 cfs 56,042 cf
Link SP-1: Study Point #1	Inflow=13.70 cfs 52,747 cf Primary=13.70 cfs 52,747 cf
Link SP-2: Study Point #2	Inflow=2.60 cfs 9,562 cf Primary=2.60 cfs 9,562 cf
Link SP-3: Study Point #3	Inflow=2.72 cfs 8,626 cf Primary=2.72 cfs 8,626 cf

Total Runoff Area = 506,116 sf Runoff Volume = 153,984 cf Average Runoff Depth = 3.65"
100.00% Pervious = 506,116 sf 0.00% Impervious = 0 sf

Summary for Subcatchment E-1: Flow North to Wetland "D"

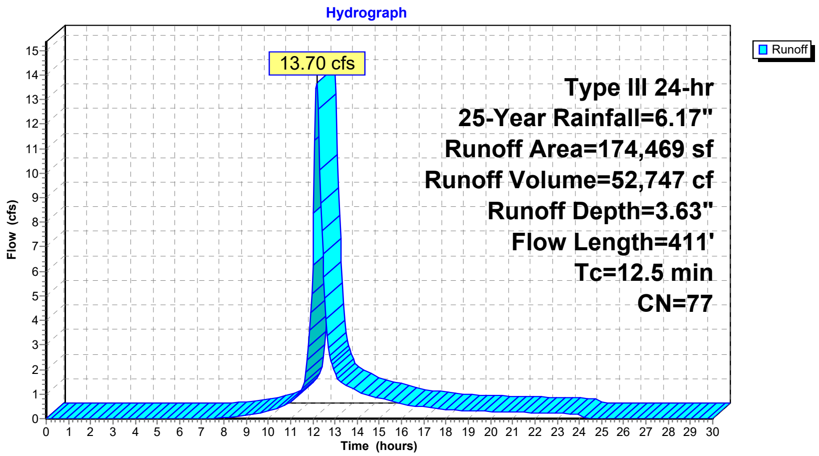
Runoff = 13.70 cfs @ 12.17 hrs, Volume= 52,747 cf, Depth= 3.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
169,906	77	Woods, Good, HSG D
174,469	77	Weighted Average
174,469		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.7	361	0.2627	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.5	411	Total			

Subcatchment E-1: Flow North to Wetland "D"



Summary for Subcatchment E-2: Flow West to Wetlands "F"

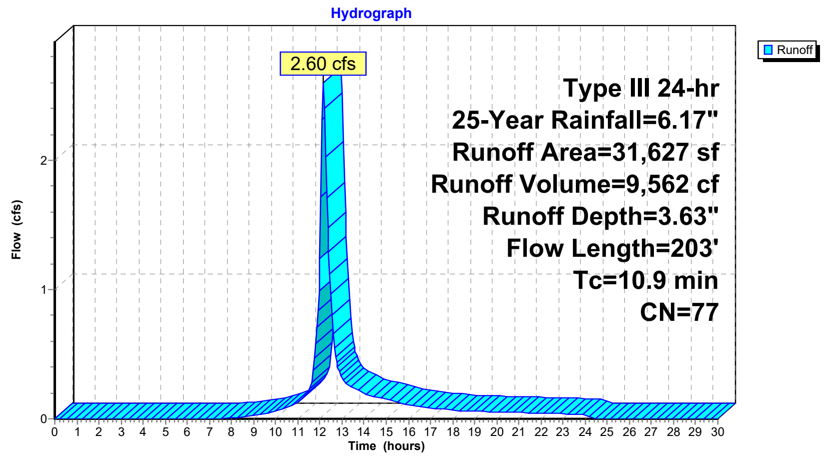
Runoff = 2.60 cfs @ 12.15 hrs, Volume= 9,562 cf, Depth= 3.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
31,627	77	Woods, Good, HSG D
31,627		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9	50	0.1836	0.09		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.0	153	0.2729	1.31		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
10.9	203	Total			

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

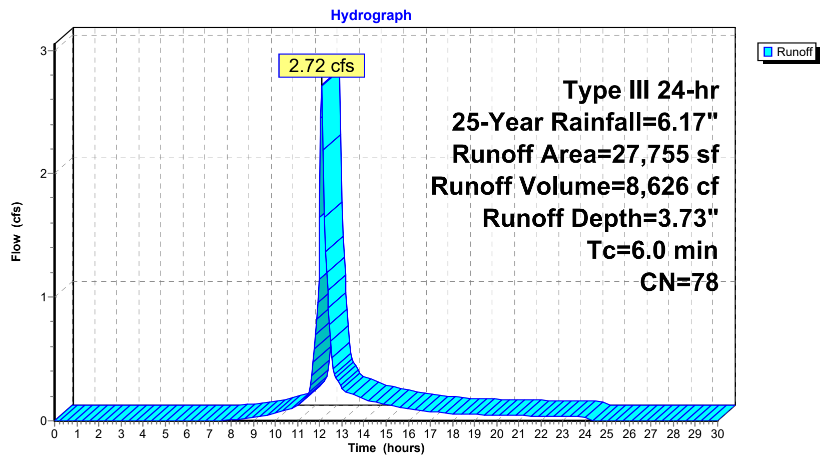
Runoff = 2.72 cfs @ 12.09 hrs, Volume= 8,626 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

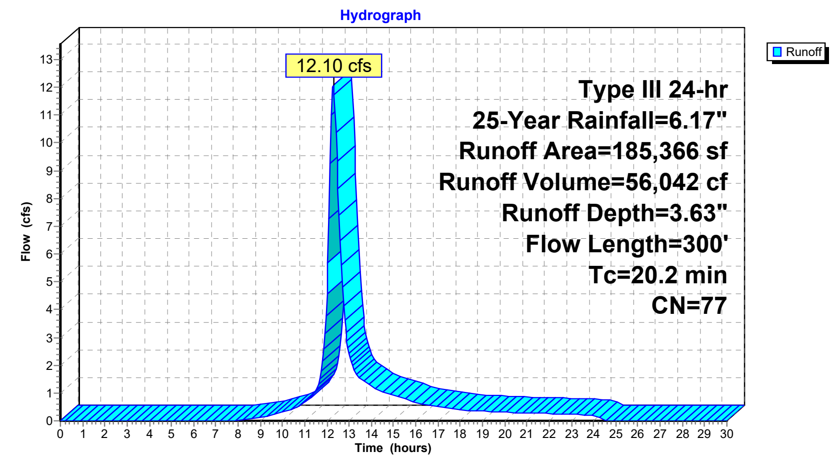
Runoff = 12.10 cfs @ 12.28 hrs, Volume= 56,042 cf, Depth= 3.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

Subcatchment E-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment E-5: Off-Site Runoff NorthEast

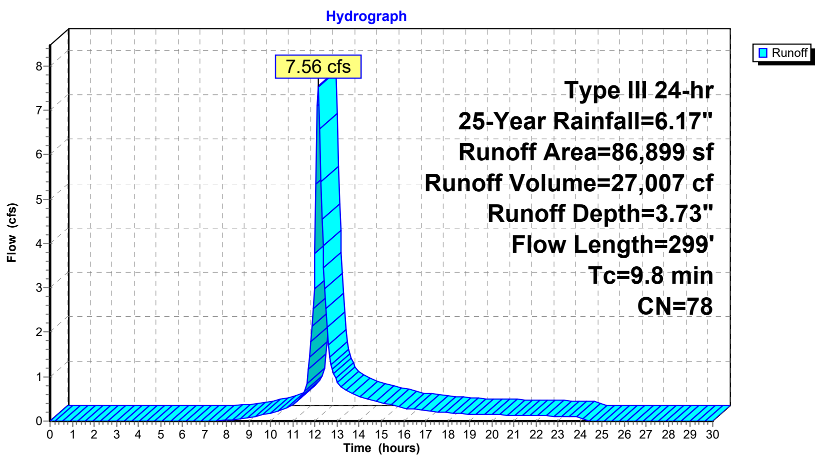
Runoff = 7.56 cfs @ 12.14 hrs, Volume= 27,007 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

	Area (sf)	CN	Description
	3,378	91	Gravel roads, HSG D
	75,337	77	Woods, Good, HSG D
*	8,184	77	Wetlands, Good, HSG D
	86,899	78	Weighted Average
	86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

Subcatchment E-5: Off-Site Runoff NorthEast



Summary for Pond 1P: On-Site Depression

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 3.73" for 25-Year event
Inflow = 7.56 cfs @ 12.14 hrs, Volume= 27,007 cf
Outflow = 0.02 cfs @ 24.21 hrs, Volume= 1,277 cf, Atten= 100%, Lag= 724.0 min
Discarded = 0.02 cfs @ 24.21 hrs, Volume= 1,277 cf
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 97.33' @ 24.21 hrs Surf.Area= 9,521 sf Storage= 26,139 cf

Plug-Flow detention time= 664.6 min calculated for 1,274 cf (5% of inflow)
Center-of-Mass det. time= 430.6 min (1,252.1 - 821.5)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)

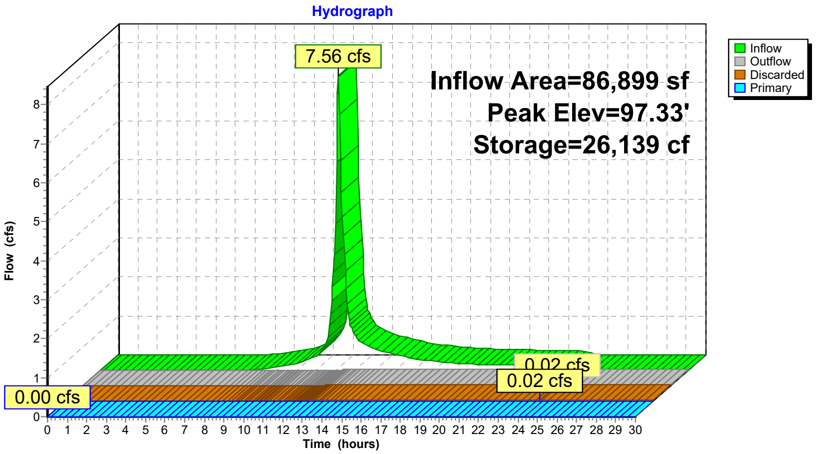
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.02 cfs @ 24.21 hrs HW=97.33' (Free Discharge)
└1=Exfiltration (D Soil) (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)
└2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 1P: On-Site Depression



Summary for Pond SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 3.63" for 25-Year event
Inflow = 12.10 cfs @ 12.28 hrs, Volume= 56,042 cf
Outflow = 5.06 cfs @ 12.69 hrs, Volume= 56,042 cf, Atten= 58%, Lag= 24.4 min
Primary = 5.06 cfs @ 12.69 hrs, Volume= 56,042 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 49.76' @ 12.69 hrs Surf.Area= 10,785 sf Storage= 11,384 cf

Plug-Flow detention time= 14.0 min calculated for 55,948 cf (100% of inflow)
Center-of-Mass det. time= 13.9 min (847.5 - 833.6)

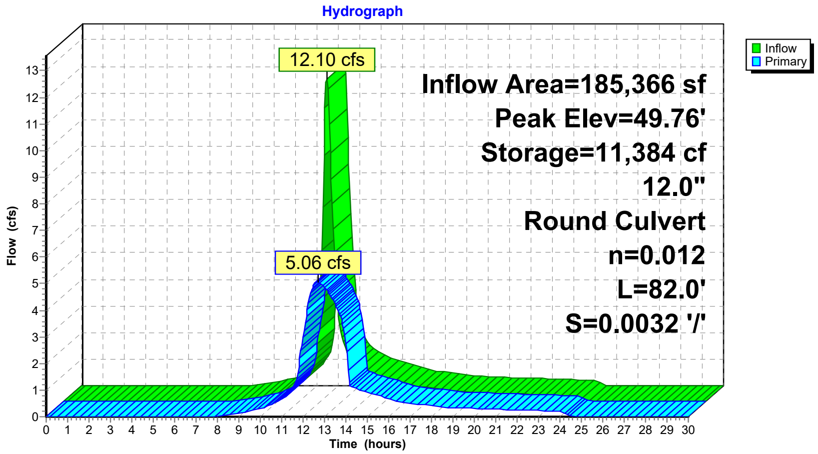
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	**12.0" Round Culvert** L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=5.05 cfs @ 12.69 hrs HW=49.76' (Free Discharge)
└1=Culvert (Barrel Controls 5.05 cfs @ 6.44 fps)

Pond SP-4: Study Point #4

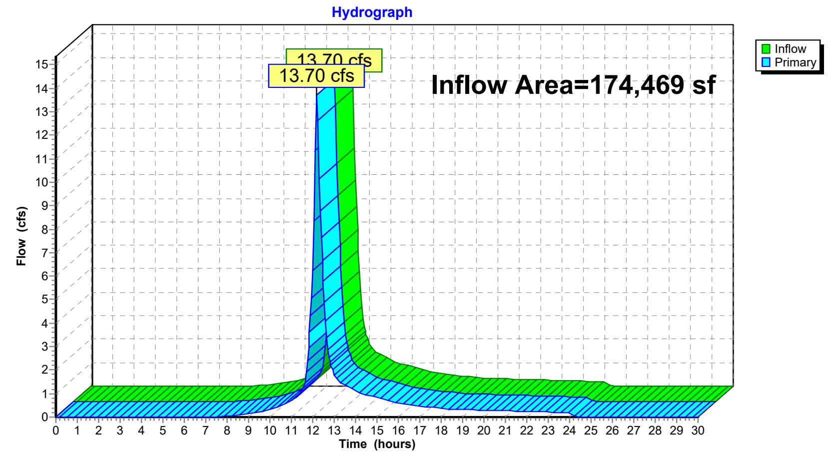


Summary for Link SP-1: Study Point #1

Inflow Area = 174,469 sf, 0.00% Impervious, Inflow Depth = 3.63" for 25-Year event
Inflow = 13.70 cfs @ 12.17 hrs, Volume= 52,747 cf
Primary = 13.70 cfs @ 12.17 hrs, Volume= 52,747 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

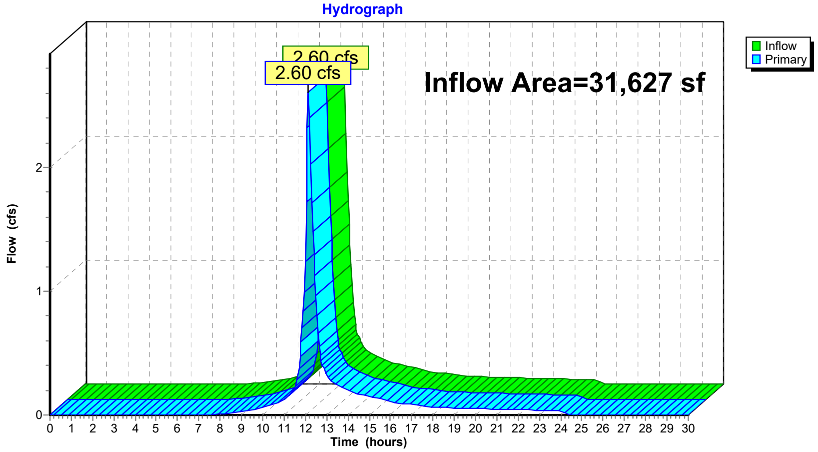


Summary for Link SP-2: Study Point #2

Inflow Area = 31,627 sf, 0.00% Impervious, Inflow Depth = 3.63" for 25-Year event
Inflow = 2.60 cfs @ 12.15 hrs, Volume= 9,562 cf
Primary = 2.60 cfs @ 12.15 hrs, Volume= 9,562 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

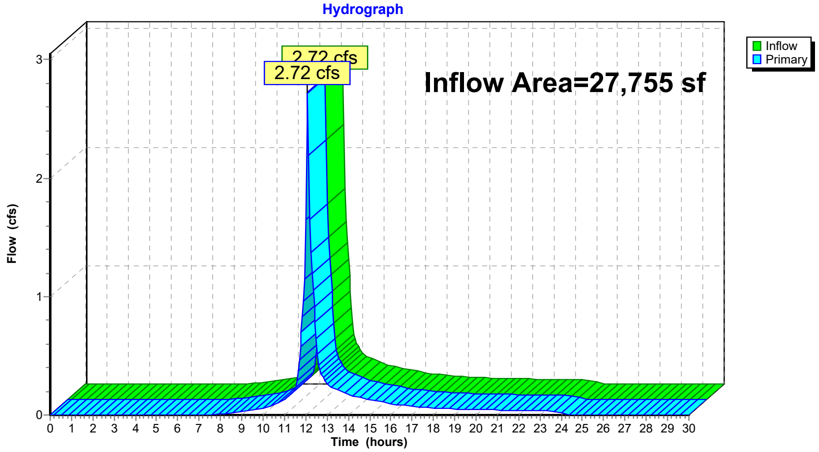


Summary for Link SP-3: Study Point #3

Inflow Area = 27,755 sf, 0.00% Impervious, Inflow Depth = 3.73" for 25-Year event
Inflow = 2.72 cfs @ 12.09 hrs, Volume= 8,626 cf
Primary = 2.72 cfs @ 12.09 hrs, Volume= 8,626 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D" — Runoff Area=174,469 sf 0.00% Impervious Runoff Depth=6.01"
Flow Length=411' Tc=12.5 min CN=77 Runoff=22.50 cfs 87,423 cf

Subcatchment E-2: Flow West to Wetlands "F" — Runoff Area=31,627 sf 0.00% Impervious Runoff Depth=6.01"
Flow Length=203' Tc=10.9 min CN=77 Runoff=4.27 cfs 15,848 cf

Subcatchment E-3: Flow Southwest Off-Site — Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=6.13"
Tc=6.0 min CN=78 Runoff=4.42 cfs 14,190 cf

Subcatchment E-4: Flow Southeast to Wetlands "A" — Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=6.01"
Flow Length=300' Tc=20.2 min CN=77 Runoff=19.94 cfs 92,883 cf

Subcatchment E-5: Off-Site Runoff NorthEast — Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=6.13"
Flow Length=299' Tc=9.8 min CN=78 Runoff=12.27 cfs 44,426 cf

Pond 1P: On-Site Depression — Peak Elev=98.91' Storage=43,273 cf Inflow=12.27 cfs 44,426 cf
Discarded=0.03 cfs 1,682 cf Primary=0.00 cfs 0 cf Outflow=0.03 cfs 1,682 cf

Pond SP-4: Study Point #4 — Peak Elev=50.74' Storage=25,057 cf Inflow=19.94 cfs 92,883 cf
12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=6.01 cfs 92,883 cf

Link SP-1: Study Point #1 — Inflow=22.50 cfs 87,423 cf
Primary=22.50 cfs 87,423 cf

Link SP-2: Study Point #2 — Inflow=4.27 cfs 15,848 cf
Primary=4.27 cfs 15,848 cf

Link SP-3: Study Point #3 — Inflow=4.42 cfs 14,190 cf
Primary=4.42 cfs 14,190 cf

Total Runoff Area = 506,116 sf Runoff Volume = 254,769 cf Average Runoff Depth = 6.04"
100.00% Pervious = 506,116 sf 0.00% Impervious = 0 sf

Summary for Subcatchment E-1: Flow North to Wetland "D"

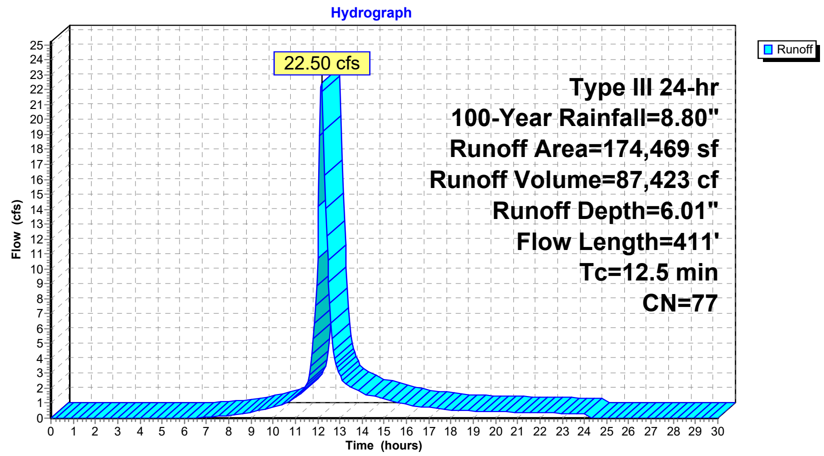
Runoff = 22.50 cfs @ 12.17 hrs, Volume= 87,423 cf, Depth= 6.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
169,906	77	Woods, Good, HSG D
174,469	77	Weighted Average
174,469		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.7	361	0.2627	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.5	411	Total			

Subcatchment E-1: Flow North to Wetland "D"



Summary for Subcatchment E-2: Flow West to Wetlands "F"

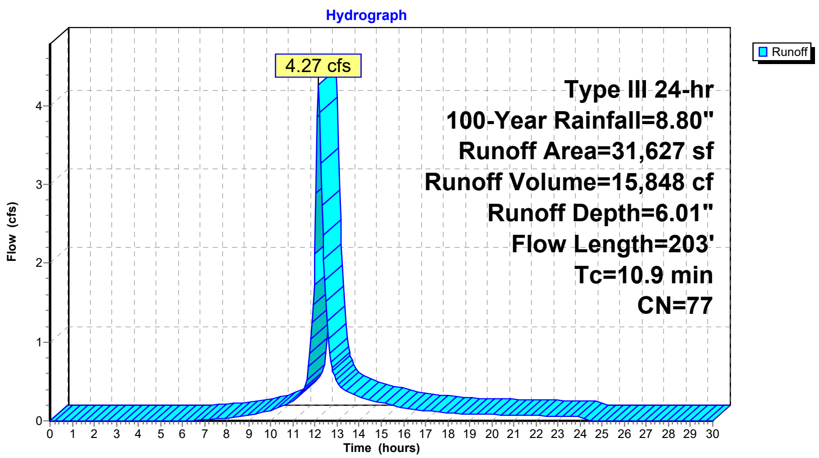
Runoff = 4.27 cfs @ 12.15 hrs, Volume= 15,848 cf, Depth= 6.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
31,627	77	Woods, Good, HSG D
31,627		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.9	50	0.1836	0.09		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.0	153	0.2729	1.31		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
10.9	203	Total			

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

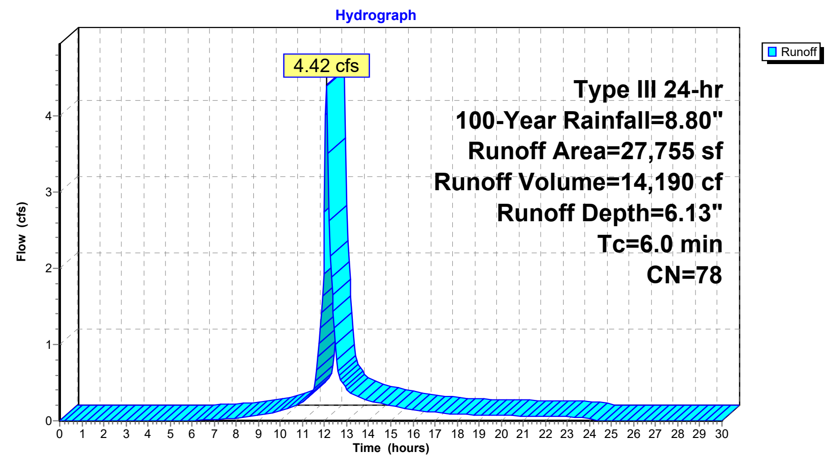
Runoff = 4.42 cfs @ 12.09 hrs, Volume= 14,190 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

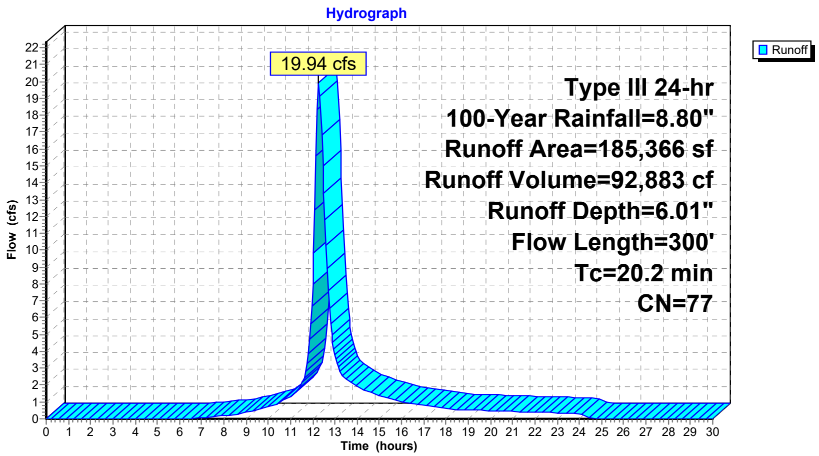
Runoff = 19.94 cfs @ 12.27 hrs, Volume= 92,883 cf, Depth= 6.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

Subcatchment E-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment E-5: Off-Site Runoff NorthEast

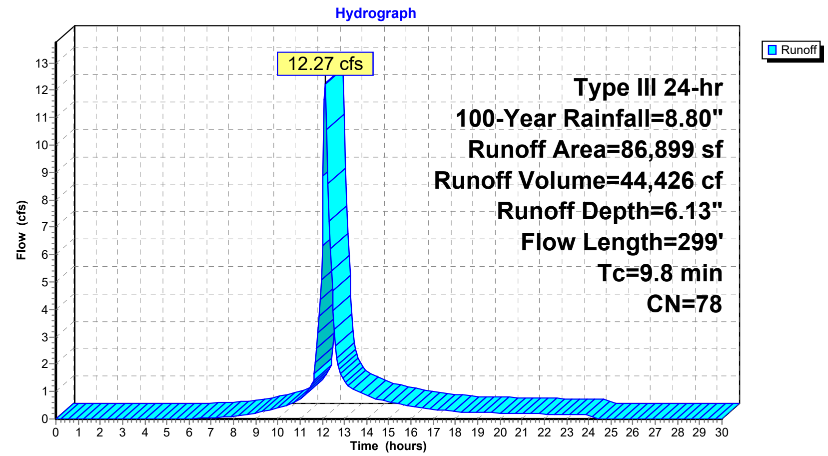
Runoff = 12.27 cfs @ 12.14 hrs, Volume= 44,426 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

	Area (sf)	CN	Description
	3,378	91	Gravel roads, HSG D
	75,337	77	Woods, Good, HSG D
*	8,184	77	Wetlands, Good, HSG D
	86,899	78	Weighted Average
	86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

Subcatchment E-5: Off-Site Runoff NorthEast



Summary for Pond 1P: On-Site Depression

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 6.13" for 100-Year event
Inflow = 12.27 cfs @ 12.14 hrs, Volume= 44,426 cf
Outflow = 0.03 cfs @ 24.22 hrs, Volume= 1,682 cf, Atten= 100%, Lag= 724.7 min
Discarded = 0.03 cfs @ 24.22 hrs, Volume= 1,682 cf
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 98.91' @ 24.22 hrs Surf.Area= 12,355 sf Storage= 43,273 cf

Plug-Flow detention time= 720.8 min calculated for 1,682 cf (4% of inflow)
Center-of-Mass det. time= 433.0 min (1,240.4 - 807.4)

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)

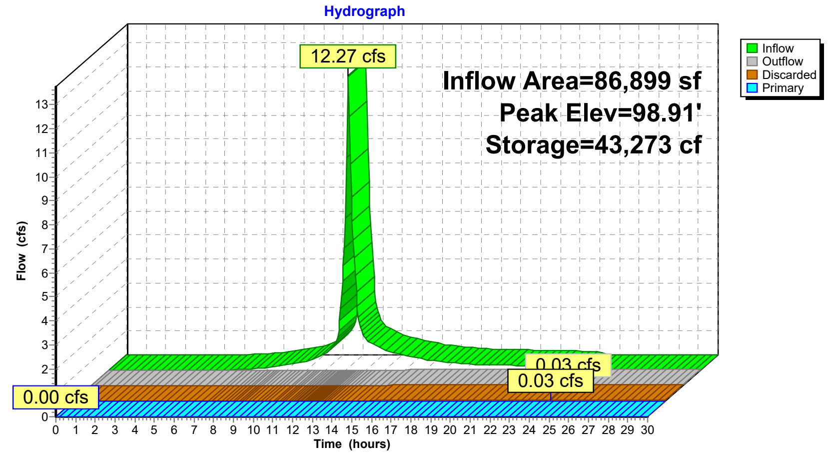
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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 Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.03 cfs @ 24.22 hrs HW=98.91' (Free Discharge)
└─1=Exfiltration (D Soil) (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)
└─2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 1P: On-Site Depression



Summary for Pond SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 6.01" for 100-Year event
Inflow = 19.94 cfs @ 12.27 hrs, Volume= 92,883 cf
Outflow = 6.01 cfs @ 12.78 hrs, Volume= 92,883 cf, Atten= 70%, Lag= 30.5 min
Primary = 6.01 cfs @ 12.78 hrs, Volume= 92,883 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 50.74' @ 12.78 hrs Surf.Area= 18,020 sf Storage= 25,057 cf

Plug-Flow detention time= 28.8 min calculated for 92,729 cf (100% of inflow)
Center-of-Mass det. time= 28.8 min (848.0 - 819.2)

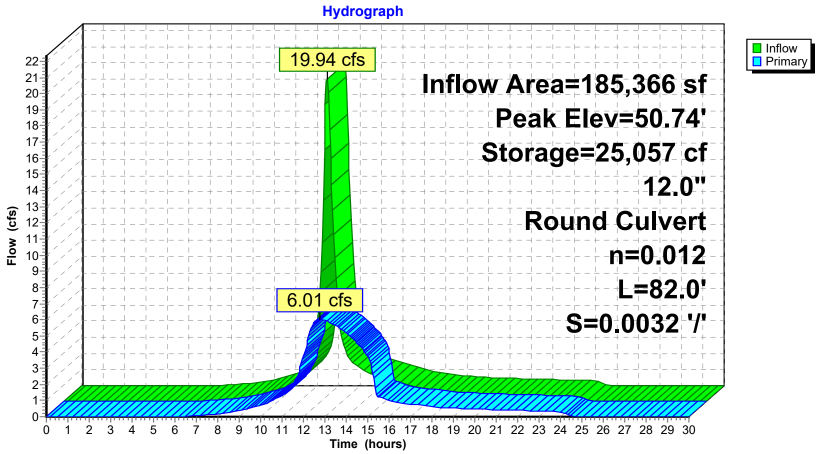
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	12.0" Round Culvert L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=6.01 cfs @ 12.78 hrs HW=50.74' (Free Discharge)
└1=Culvert (Barrel Controls 6.01 cfs @ 7.65 fps)

Pond SP-4: Study Point #4

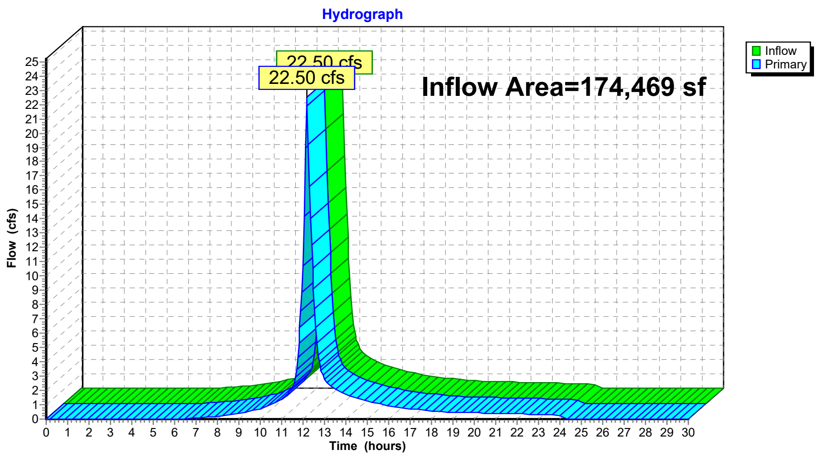


Summary for Link SP-1: Study Point #1

Inflow Area = 174,469 sf, 0.00% Impervious, Inflow Depth = 6.01" for 100-Year event
Inflow = 22.50 cfs @ 12.17 hrs, Volume= 87,423 cf
Primary = 22.50 cfs @ 12.17 hrs, Volume= 87,423 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

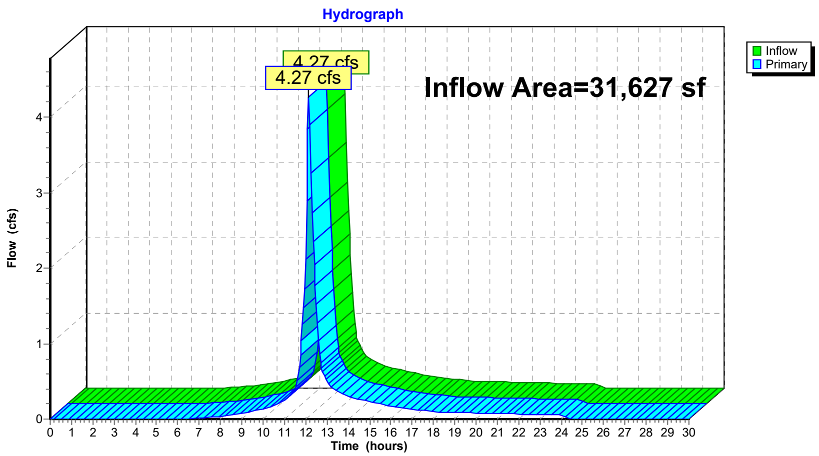


Summary for Link SP-2: Study Point #2

Inflow Area = 31,627 sf, 0.00% Impervious, Inflow Depth = 6.01" for 100-Year event
Inflow = 4.27 cfs @ 12.15 hrs, Volume= 15,848 cf
Primary = 4.27 cfs @ 12.15 hrs, Volume= 15,848 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

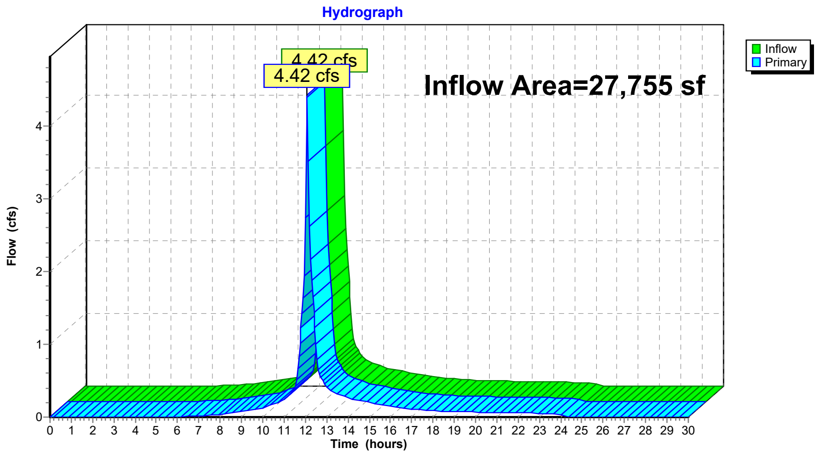


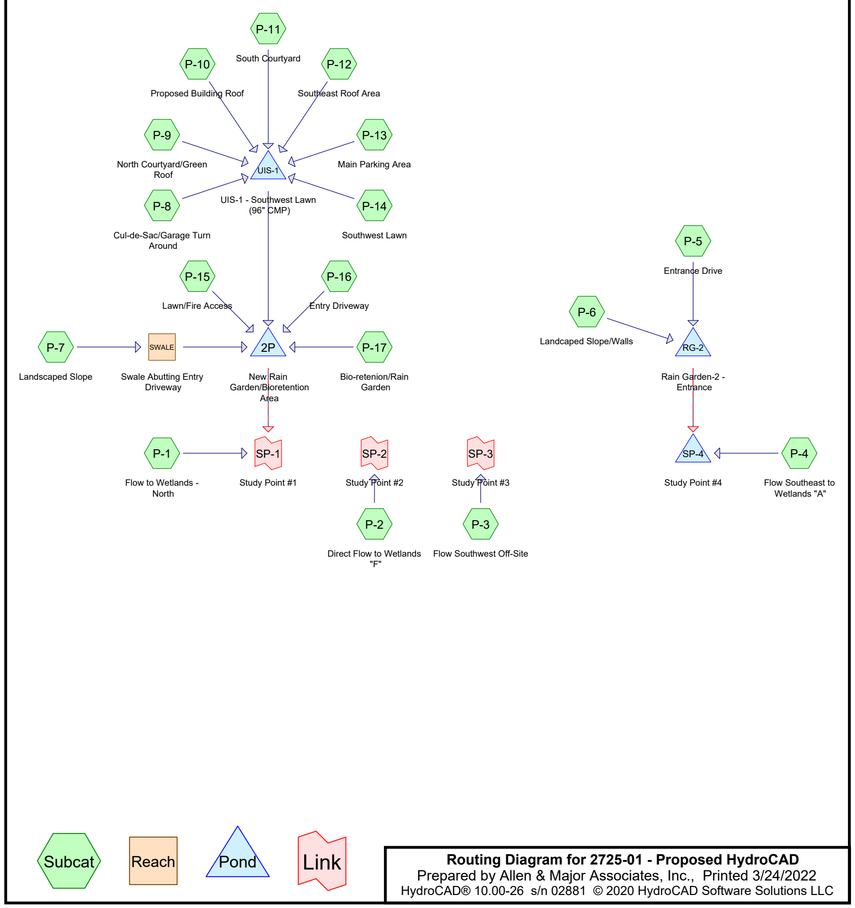
Summary for Link SP-3: Study Point #3

Inflow Area = 27,755 sf, 0.00% Impervious, Inflow Depth = 6.13" for 100-Year event
Inflow = 4.42 cfs @ 12.09 hrs, Volume= 14,190 cf
Primary = 4.42 cfs @ 12.09 hrs, Volume= 14,190 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3





Routing Diagram for 2725-01 - Proposed HydroCAD
Prepared by Allen & Major Associates, Inc., Printed 3/24/2022
HydroCAD® 10.00-26 s/n 02881 © 2020 HydroCAD Software Solutions LLC

Project Notes

Rainfall events imported from "NRCS-Rain.txt" for 4314 MA Wayland Middlesex County South

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
134,144	80	>75% Grass cover, Good, HSG D (P-1, P-13, P-14, P-15, P-16, P-3, P-4, P-5, P-8, P-9)
59,816	73	Brush, Good, HSG D (P-17, P-6, P-7)
3,854	80	GrassPave2, Good, HSG D (P-15)
41,569	98	Paved parking, HSG D (P-14, P-15, P-5, P-7, P-8)
43,618	98	Unconnected pavement, HSG D (P-11, P-13, P-16, P-3, P-4, P-6)
62,664	98	Unconnected roofs, HSG D (P-10, P-12, P-9)
160,451	77	Woods, Good, HSG D (P-1, P-2, P-3, P-4)
506,116	83	TOTAL AREA

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
0	HSG C	
506,116	HSG D	P-1, P-10, P-11, P-12, P-13, P-14, P-15, P-16, P-17, P-2, P-3, P-4, P-5, P-6, P-7, P-8, P-9
0	Other	
506,116		TOTAL AREA

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Subcatchment Numbers
0	0	0	134,144	0	134,144	>75% Grass cover, Good	P-1, P-13, P-14, P-15, P-16, P-3, P-4, P-5, P-8, P-9
0	0	0	59,816	0	59,816	Brush, Good	P-17, P-6, P-7
0	0	0	3,854	0	3,854	GrassPave2, Good	P-15
0	0	0	41,569	0	41,569	Paved parking	P-14, P-15, P-5, P-7, P-8
0	0	0	43,618	0	43,618	Unconnected pavement	P-11, P-13, P-16, P-3, P-4, P-6
0	0	0	62,664	0	62,664	Unconnected roofs	P-10, P-12, P-9
0	0	0	160,451	0	160,451	Woods, Good	P-1, P-2, P-3, P-4
0	0	0	506,116	0	506,116	TOTAL AREA	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	2P	57.00	56.00	20.0	0.0500	0.012	24.0	0.0	0.0
2	RG-2	47.20	46.60	120.0	0.0050	0.013	12.0	0.0	0.0
3	SP-4	46.64	46.38	82.0	0.0032	0.012	12.0	0.0	0.0
4	UIS-1	101.50	99.50	100.0	0.0200	0.013	12.0	0.0	0.0

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North — Runoff Area=45,886 sf 0.00% Impervious Runoff Depth=1.30"
Flow Length=148' Tc=9.7 min CN=78 Runoff=1.37 cfs 4,981 cf

Subcatchment P-10: Proposed Building Roof — Runoff Area=30,352 sf 100.00% Impervious Runoff Depth=3.01"
Tc=6.0 min CN=98 Runoff=2.14 cfs 7,607 cf

Subcatchment P-11: South Courtyard — Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=3.01"
Tc=6.0 min CN=98 Runoff=1.42 cfs 5,057 cf

Subcatchment P-12: Southeast Roof Area — Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=3.01"
Tc=6.0 min CN=98 Runoff=1.92 cfs 6,830 cf

Subcatchment P-13: Main Parking Area — Runoff Area=18,475 sf 73.00% Impervious Runoff Depth=2.48"
Tc=6.0 min CN=93 Runoff=1.17 cfs 3,825 cf

Subcatchment P-14: Southwest Lawn — Runoff Area=24,170 sf 21.35% Impervious Runoff Depth=1.72"
Flow Length=245' Tc=13.3 min CN=84 Runoff=0.88 cfs 3,456 cf

Subcatchment P-15: Lawn/Fire Access — Runoff Area=43,949 sf 21.71% Impervious Runoff Depth=1.72"
Tc=6.0 min CN=84 Runoff=1.99 cfs 6,284 cf

Subcatchment P-16: Entry Driveway — Runoff Area=12,275 sf 65.60% Impervious Runoff Depth=2.39"
Tc=6.0 min CN=92 Runoff=0.75 cfs 2,443 cf

Subcatchment P-17: Bio-retenion/Rain Garden — Runoff Area=23,236 sf 0.00% Impervious Runoff Depth=1.01"
Tc=6.0 min CN=73 Runoff=0.58 cfs 1,953 cf

Subcatchment P-2: Direct Flow to Wetlands "F" — Runoff Area=28,310 sf 0.00% Impervious Runoff Depth=1.24"
Flow Length=230' Tc=9.7 min CN=77 Runoff=0.80 cfs 2,926 cf

Subcatchment P-3: Flow Southwest Off-Site — Runoff Area=13,369 sf 4.23% Impervious Runoff Depth=1.37"
Flow Length=62' Slope=0.3000 '/' Tc=7.4 min CN=79 Runoff=0.46 cfs 1,523 cf

Subcatchment P-4: Flow Southeast to Wetlands "A" — Runoff Area=123,881 sf 0.67% Impervious Runoff Depth=1.30"
Flow Length=186' Tc=14.0 min CN=78 Runoff=3.28 cfs 13,449 cf

Subcatchment P-5: Entrance Drive — Runoff Area=18,436 sf 46.85% Impervious Runoff Depth=2.03"
Tc=6.0 min CN=88 Runoff=0.98 cfs 3,123 cf

Subcatchment P-6: Landcaped Slope/Walls — Runoff Area=13,824 sf 3.65% Impervious Runoff Depth=1.01"
Flow Length=175' Tc=11.7 min UI Adjusted CN=73 Runoff=0.29 cfs 1,162 cf

Subcatchment P-7: Landscaped Slope — Runoff Area=24,883 sf 6.52% Impervious Runoff Depth=1.12"
Tc=6.0 min CN=75 Runoff=0.71 cfs 2,325 cf

Subcatchment P-8: Cul-de-Sac/Garage Turn Around — Runoff Area=22,308 sf 74.44% Impervious Runoff Depth=2.48"
Tc=6.0 min CN=93 Runoff=1.41 cfs 4,618 cf

Subcatchment P-9: North Courtyard/Green Roof — Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=1.87"
Tc=6.0 min CN=86 Runoff=0.76 cfs 2,389 cf

Reach SWALE: Swale Abutting Entry Driveway — Avg. Flow Depth=0.20' Max Vel=1.21 fps Inflow=0.71 cfs 2,325 cf
n=0.100 L=427.0' S=0.0714 '/' Capacity=6.48 cfs Outflow=0.59 cfs 2,325 cf

Pond 2P: New Rain Garden/Bioretention Area — Peak Elev=58.72' Storage=4,498 cf Inflow=3.82 cfs 14,232 cf
Discarded=0.23 cfs 9,977 cf Primary=1.17 cfs 4,253 cf Secondary=0.00 cfs 0 cf Outflow=1.40 cfs 14,230 cf

Pond RG-2: Rain Garden-2 - Entrance — Peak Elev=51.27' Storage=600 cf Inflow=1.21 cfs 4,285 cf
Primary=1.16 cfs 3,929 cf Secondary=0.00 cfs 0 cf Outflow=1.16 cfs 3,929 cf

Pond SP-4: Study Point #4 — Peak Elev=48.35' Storage=1,044 cf Inflow=4.24 cfs 17,378 cf
12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=3.23 cfs 17,378 cf

Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP) — Peak Elev=102.82' Storage=13,314 cf Inflow=9.48 cfs 33,782 cf
Discarded=0.72 cfs 32,555 cf Primary=0.17 cfs 1,227 cf Outflow=0.89 cfs 33,782 cf

Link SP-1: Study Point #1 — Inflow=1.82 cfs 9,235 cf
Primary=1.82 cfs 9,235 cf

Link SP-2: Study Point #2 — Inflow=0.80 cfs 2,926 cf
Primary=0.80 cfs 2,926 cf

Link SP-3: Study Point #3 — Inflow=0.46 cfs 1,523 cf
Primary=0.46 cfs 1,523 cf

Total Runoff Area = 506,116 sf Runoff Volume = 73,951 cf Average Runoff Depth = 1.75"
70.79% Pervious = 358,265 sf 29.21% Impervious = 147,851 sf

Summary for Subcatchment P-1: Flow to Wetlands - North

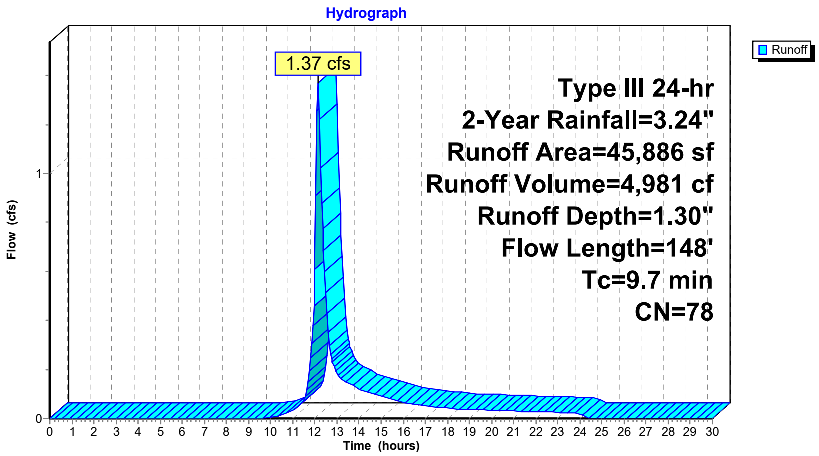
Runoff = 1.37 cfs @ 12.15 hrs, Volume= 4,981 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
9,993	80	>75% Grass cover, Good, HSG D
35,893	77	Woods, Good, HSG D
45,886	78	Weighted Average
45,886		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	50	0.2120	0.10		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
1.3	98	0.2620	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	148	Total			

Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

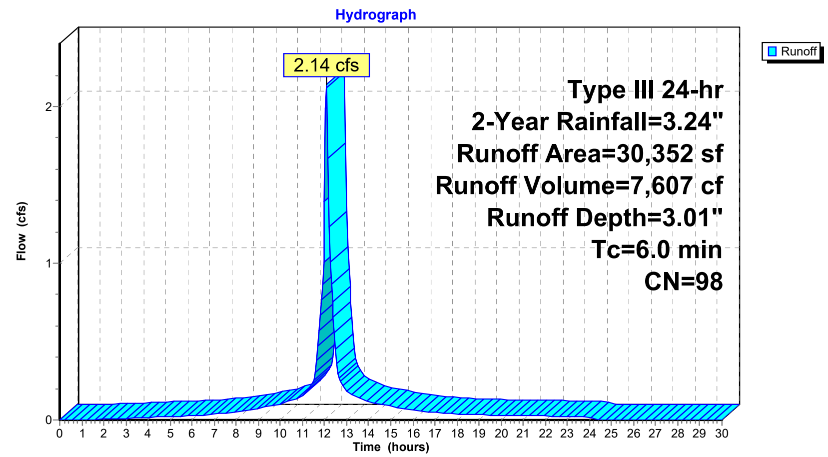
Runoff = 2.14 cfs @ 12.09 hrs, Volume= 7,607 cf, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
30,352	98	Unconnected roofs, HSG D
30,352		100.00% Impervious Area
30,352		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

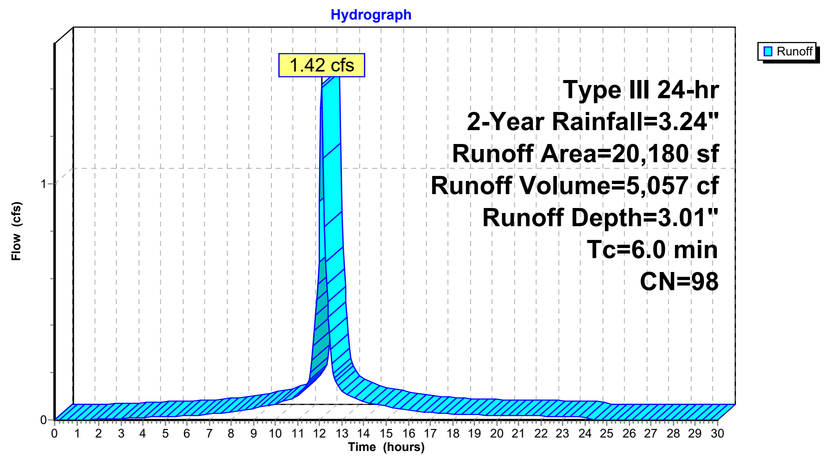
Runoff = 1.42 cfs @ 12.09 hrs, Volume= 5,057 cf, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

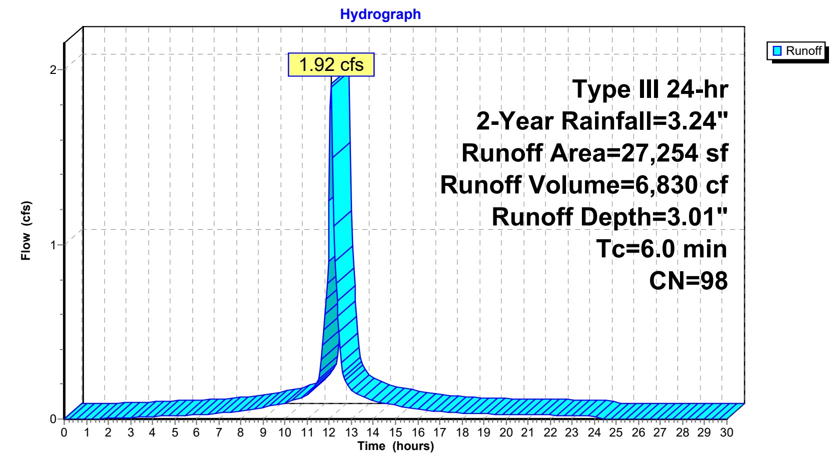
Runoff = 1.92 cfs @ 12.09 hrs, Volume= 6,830 cf, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

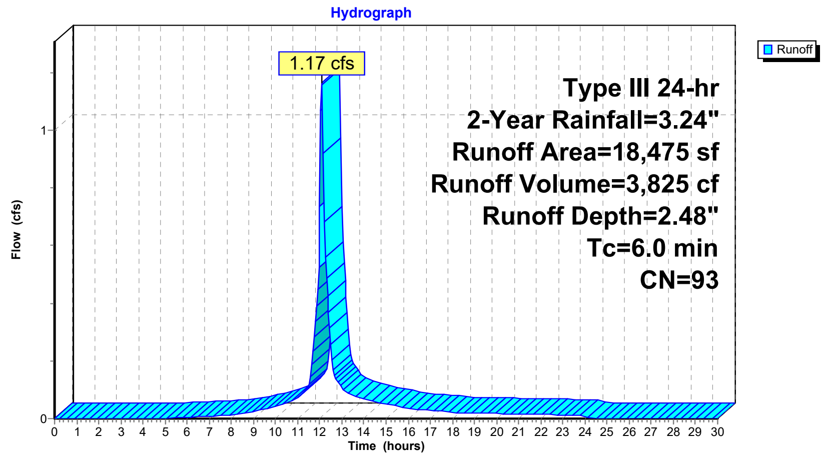
Runoff = 1.17 cfs @ 12.09 hrs, Volume= 3,825 cf, Depth= 2.48"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
13,486	98	Unconnected pavement, HSG D
4,989	80	>75% Grass cover, Good, HSG D
18,475	93	Weighted Average
4,989		27.00% Pervious Area
13,486		73.00% Impervious Area
13,486		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: Southwest Lawn

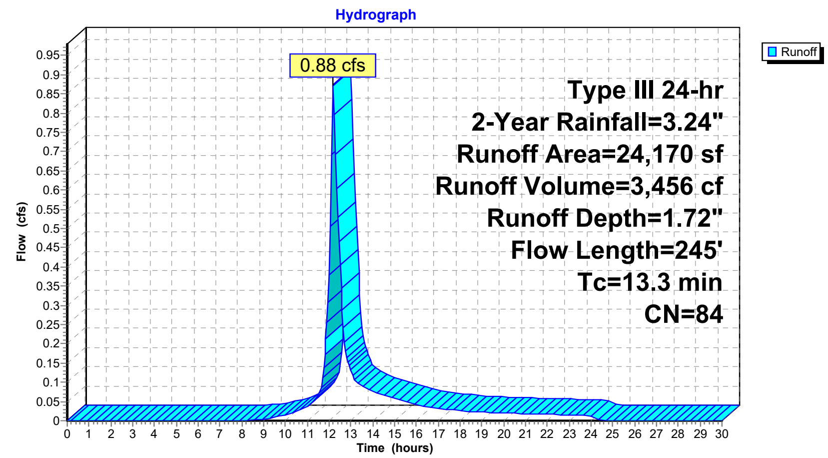
Runoff = 0.88 cfs @ 12.19 hrs, Volume= 3,456 cf, Depth= 1.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
5,161	98	Paved parking, HSG D
19,009	80	>75% Grass cover, Good, HSG D
24,170	84	Weighted Average
19,009		78.65% Pervious Area
5,161		21.35% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	50	0.0100	0.08		Sheet Flow, Grass: Dense n= 0.240 P2= 3.16"
1.9	80	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.5	115	0.0400	4.06		Shallow Concentrated Flow, Paved Kv= 20.3 fps
13.3	245	Total			

Subcatchment P-14: Southwest Lawn



Summary for Subcatchment P-15: Lawn/Fire Access

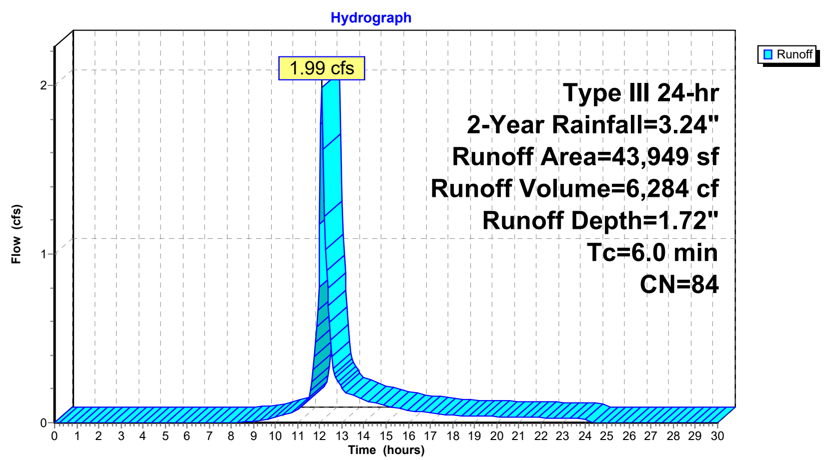
Runoff = 1.99 cfs @ 12.09 hrs, Volume= 6,284 cf, Depth= 1.72"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

	Area (sf)	CN	Description
	9,543	98	Paved parking, HSG D
*	3,854	80	GrassPave2, Good, HSG D
	30,552	80	>75% Grass cover, Good, HSG D
	43,949	84	Weighted Average
	34,406		78.29% Pervious Area
	9,543		21.71% Impervious Area

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

Subcatchment P-15: Lawn/Fire Access



Summary for Subcatchment P-16: Entry Driveway

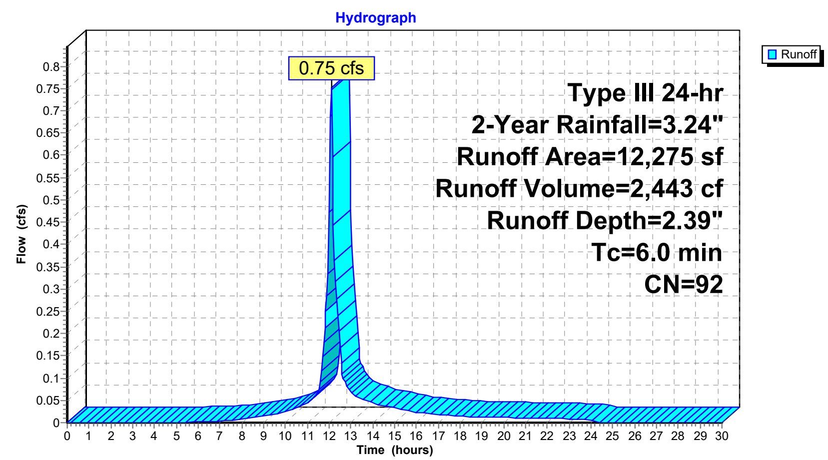
Runoff = 0.75 cfs @ 12.09 hrs, Volume= 2,443 cf, Depth= 2.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
8,053	98	Unconnected pavement, HSG D
4,222	80	>75% Grass cover, Good, HSG D
12,275	92	Weighted Average
4,222		34.40% Pervious Area
8,053		65.60% Impervious Area
8,053		100.00% Unconnected

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

Subcatchment P-16: Entry Driveway



Summary for Subcatchment P-17: Bio-retenion/Rain Garden

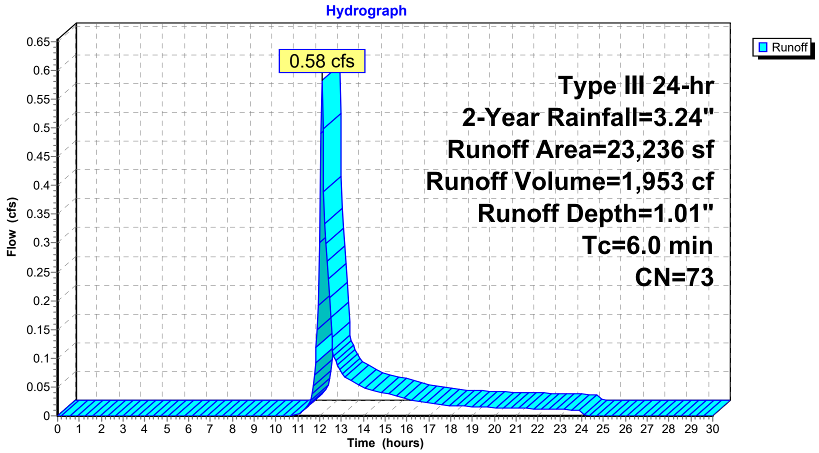
Runoff = 0.58 cfs @ 12.10 hrs, Volume= 1,953 cf, Depth= 1.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
23,236	73	Brush, Good, HSG D
0	77	Woods, Good, HSG D
23,236	73	Weighted Average
23,236		100.00% Pervious Area

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

Subcatchment P-17: Bio-retenion/Rain Garden



Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

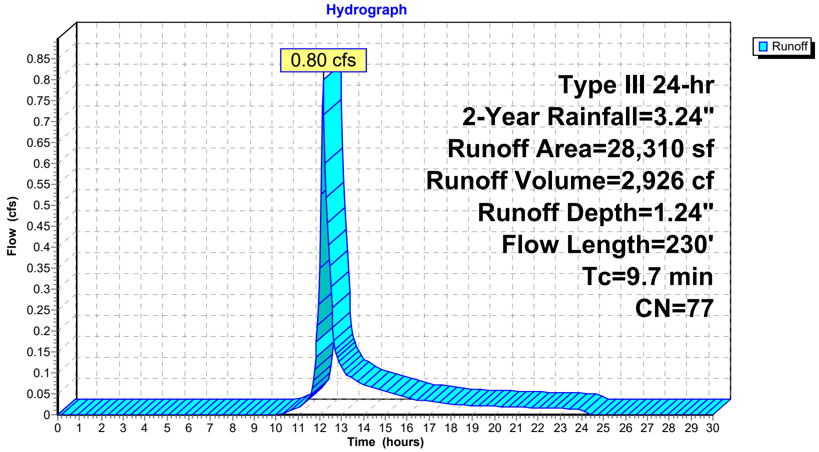
Runoff = 0.80 cfs @ 12.15 hrs, Volume= 2,926 cf, Depth= 1.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
0	80	>75% Grass cover, Good, HSG D
28,310	77	Woods, Good, HSG D
28,310	77	Weighted Average
28,310		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.2980	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.4	180	0.2580	1.27		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	230	Total			

Subcatchment P-2: Direct Flow to Wetlands "F"



Summary for Subcatchment P-3: Flow Southwest Off-Site

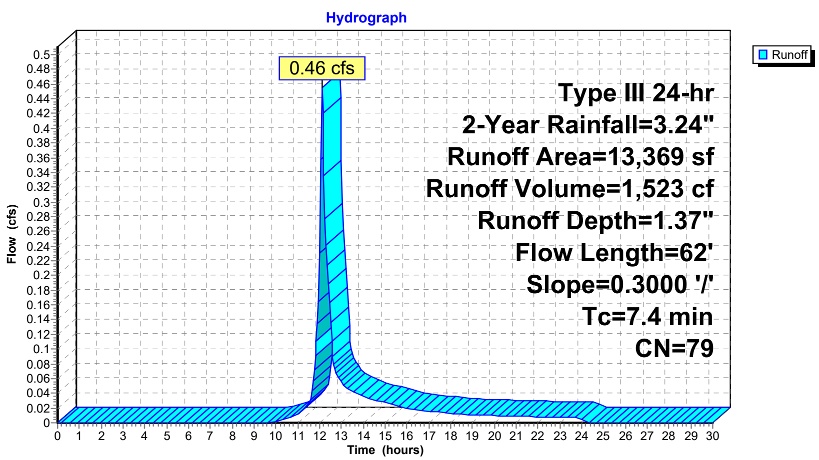
Runoff = 0.46 cfs @ 12.11 hrs, Volume= 1,523 cf, Depth= 1.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
6,978	80	>75% Grass cover, Good, HSG D
5,825	77	Woods, Good, HSG D
566	98	Unconnected pavement, HSG D
13,369	79	Weighted Average
12,803		95.77% Pervious Area
566		4.23% Impervious Area
566		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.3000	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
0.1	12	0.3000	1.37		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
7.4	62	Total			

Subcatchment P-3: Flow Southwest Off-Site



Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

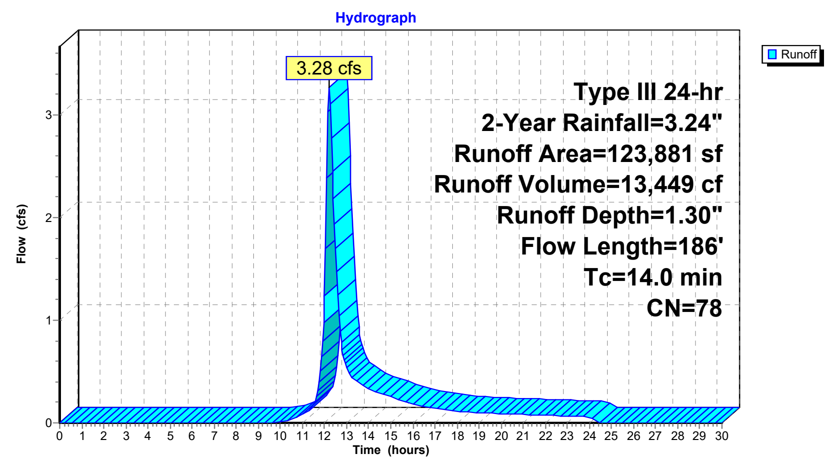
Runoff = 3.28 cfs @ 12.20 hrs, Volume= 13,449 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
90,423	77	Woods, Good, HSG D
32,630	80	>75% Grass cover, Good, HSG D
828	98	Unconnected pavement, HSG D
123,881	78	Weighted Average
123,053		99.33% Pervious Area
828		0.67% Impervious Area
828		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

Subcatchment P-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment P-5: Entrance Drive

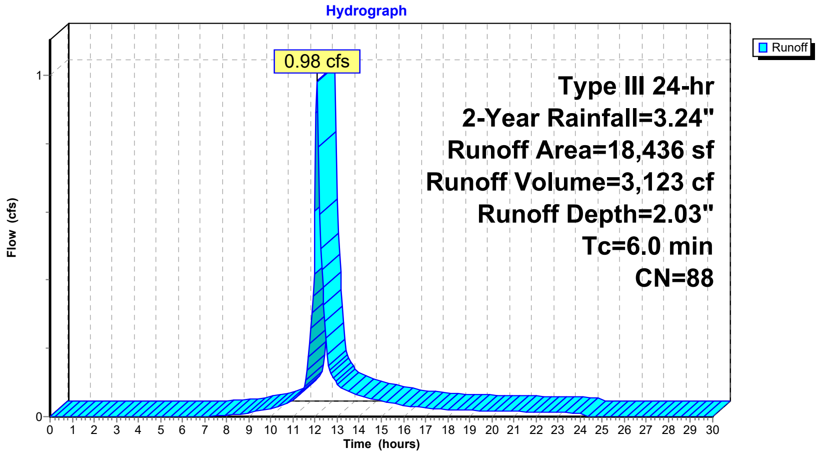
Runoff = 0.98 cfs @ 12.09 hrs, Volume= 3,123 cf, Depth= 2.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
8,637	98	Paved parking, HSG D
9,799	80	>75% Grass cover, Good, HSG D
18,436	88	Weighted Average
9,799		53.15% Pervious Area
8,637		46.85% Impervious Area

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

Subcatchment P-5: Entrance Drive



Summary for Subcatchment P-6: Landcaped Slope/Walls

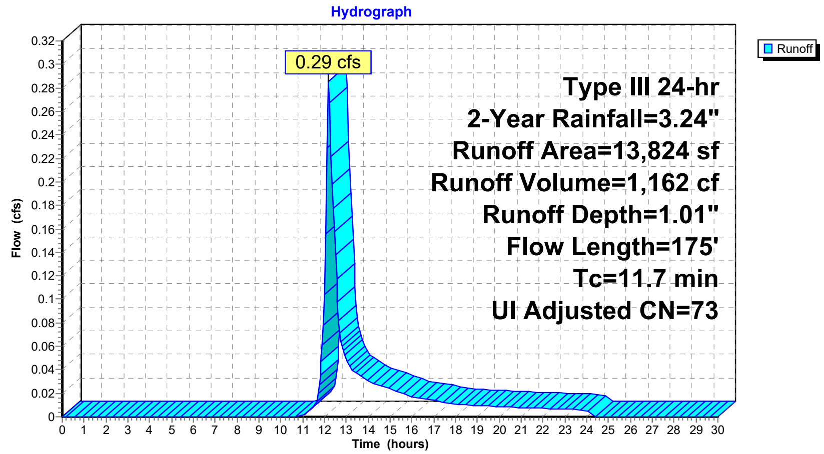
Runoff = 0.29 cfs @ 12.18 hrs, Volume= 1,162 cf, Depth= 1.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Adj	Description
13,319	73		Brush, Good, HSG D
505	98		Unconnected pavement, HSG D
13,824	74	73	Weighted Average, UI Adjusted
13,319			96.35% Pervious Area
505			3.65% Impervious Area
505			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.8	50	0.0300	0.08		Sheet Flow, Grass: Bermuda n= 0.410 P2= 3.16"
0.9	125	0.0600	2.40	6.61	Trap/Vee/Rect Channel Flow, Bot.W=4.00' D=0.50' Z= 3.0 '/' Top.W=7.00' n= 0.080 Earth, long dense weeds
11.7	175	Total			

Subcatchment P-6: Landcaped Slope/Walls



Summary for Subcatchment P-7: Landscaped Slope

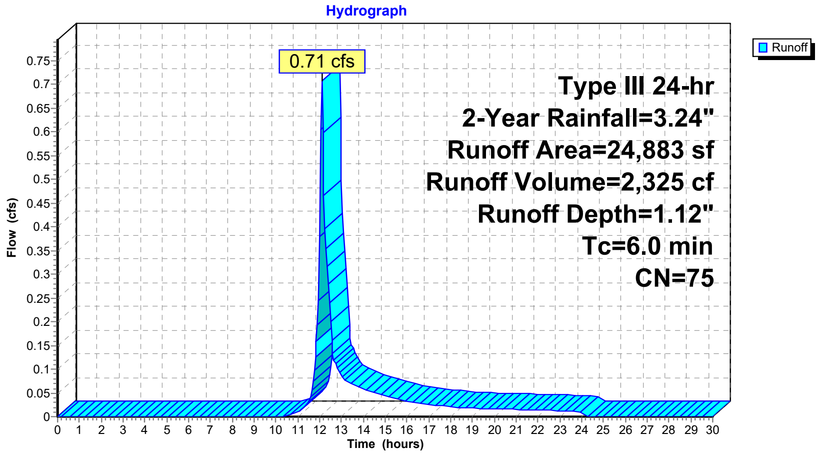
Runoff = 0.71 cfs @ 12.10 hrs, Volume= 2,325 cf, Depth= 1.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
1,622	98	Paved parking, HSG D
23,261	73	Brush, Good, HSG D
24,883	75	Weighted Average
23,261		93.48% Pervious Area
1,622		6.52% Impervious Area

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

Subcatchment P-7: Landscaped Slope



Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

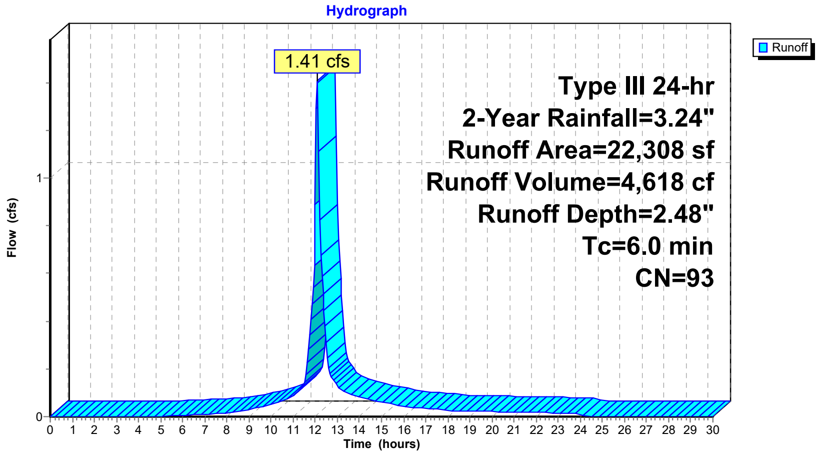
Runoff = 1.41 cfs @ 12.09 hrs, Volume= 4,618 cf, Depth= 2.48"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
16,606	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,308	93	Weighted Average
5,702		25.56% Pervious Area
16,606		74.44% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

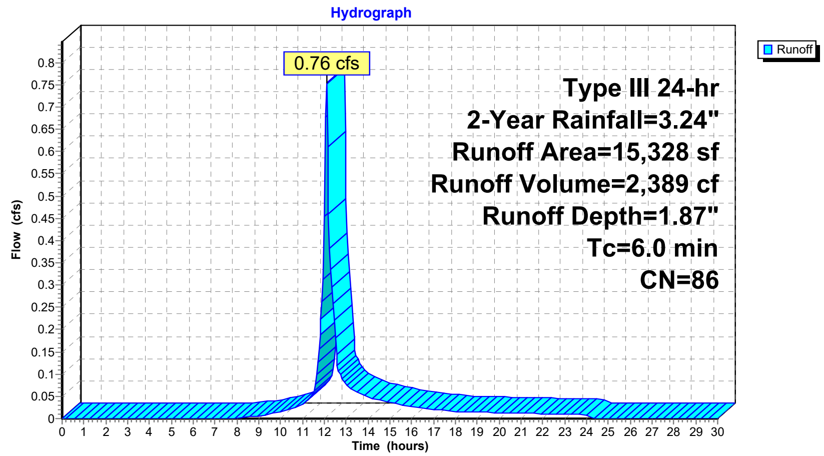
Runoff = 0.76 cfs @ 12.09 hrs, Volume= 2,389 cf, Depth= 1.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



Summary for Reach SWALE: Swale Abutting Entry Driveway

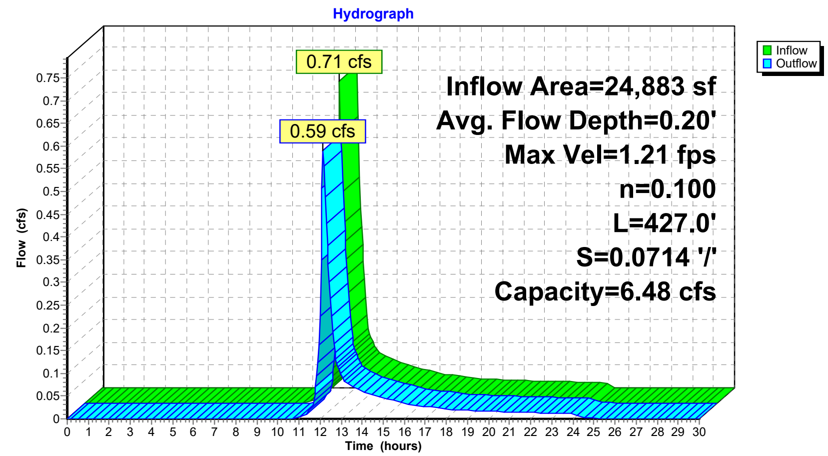
Inflow Area = 24,883 sf, 6.52% Impervious, Inflow Depth = 1.12" for 2-Year event
Inflow = 0.71 cfs @ 12.10 hrs, Volume= 2,325 cf
Outflow = 0.59 cfs @ 12.16 hrs, Volume= 2,325 cf, Atten= 17%, Lag= 3.7 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.21 fps, Min. Travel Time= 5.9 min
Avg. Velocity = 0.35 fps, Avg. Travel Time= 20.1 min

Peak Storage= 208 cf @ 12.16 hrs
Average Depth at Peak Storage= 0.20'
Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 6.48 cfs

2.00' x 0.75' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 2.0 '/' Top Width= 5.00'
Length= 427.0' Slope= 0.0714 '/'
Inlet Invert= 98.00', Outlet Invert= 67.50'

Reach SWALE: Swale Abutting Entry Driveway



Summary for Pond 2P: New Rain Garden/Bioretention Area

Inflow Area = 262,410 sf, 52.33% Impervious, Inflow Depth = 0.65" for 2-Year event
Inflow = 3.82 cfs @ 12.10 hrs, Volume= 14,232 cf
Outflow = 1.40 cfs @ 12.45 hrs, Volume= 14,230 cf, Atten= 63%, Lag= 21.1 min
Discarded = 0.23 cfs @ 12.45 hrs, Volume= 9,977 cf
Primary = 1.17 cfs @ 12.45 hrs, Volume= 4,253 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 58.72' @ 12.45 hrs Surf.Area= 4,110 sf Storage= 4,498 cf

Plug-Flow detention time= 160.2 min calculated for 14,207 cf (100% of inflow)
Center-of-Mass det. time= 160.2 min (994.3 - 834.1)

Volume	Invert	Avail.Storage	Storage Description
#1	57.00'	15,686 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
57.00	1,407	540.0	0	0	1,407
58.00	2,750	481.0	2,041	2,041	6,228
60.00	7,194	732.0	9,595	11,636	30,487
60.50	9,042	748.0	4,050	15,686	32,407

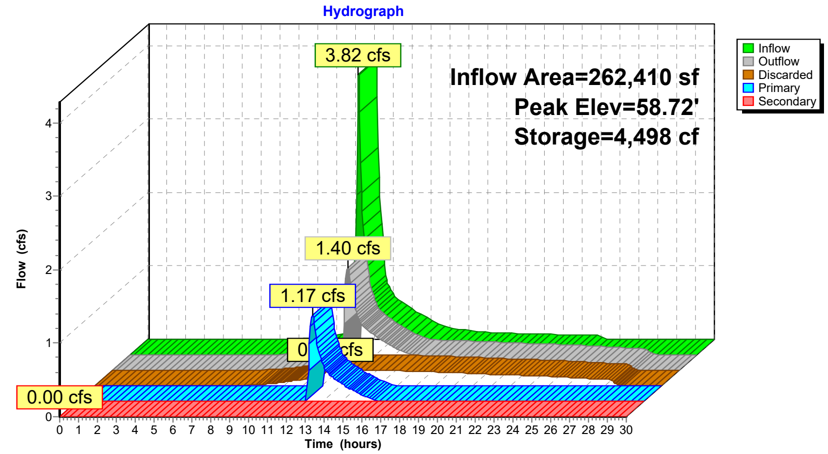
Device	Routing	Invert	Outlet Devices
#1	Primary	57.00'	24.0" Round Culvert L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 57.00' / 56.00' S= 0.0500 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 3.14 sf
#2	Device 1	58.50'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	57.00'	2.410 in/hr Exfiltration over Surface area
#4	Secondary	59.55'	10.0' long x 12.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Discarded OutFlow Max=0.23 cfs @ 12.45 hrs HW=58.72' (Free Discharge)
└3=Exfiltration (Exfiltration Controls 0.23 cfs)

Primary OutFlow Max=1.17 cfs @ 12.45 hrs HW=58.72' (Free Discharge)
└1=Culvert (Passes 1.17 cfs of 10.14 cfs potential flow)
  └2=Broad-Crested Rectangular Weir (Weir Controls 1.17 cfs @ 1.32 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=57.00' (Free Discharge)
└4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 2P: New Rain Garden/Bioretention Area



Summary for Pond RG-2: Rain Garden-2 - Entrance

```
Inflow Area =      32,260 sf,  28.34% Impervious,  Inflow Depth =  1.59"   for 2-Year event
Inflow      =      1.21 cfs @  12.10 hrs,  Volume=          4,285 cf
Outflow     =      1.16 cfs @  12.12 hrs,  Volume=          3,929 cf,  Atten= 4%,  Lag= 1.1 min
Primary     =      1.16 cfs @  12.12 hrs,  Volume=          3,929 cf
Secondary   =      0.00 cfs @   0.00 hrs,  Volume=              0 cf
```

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 51.27' @ 12.12 hrs Surf.Area= 951 sf Storage= 600 cf

Plug-Flow detention time= 91.4 min calculated for 3,929 cf (92% of inflow)
Center-of-Mass det. time= 49.1 min (878.7 - 829.5)

Volume	Invert	Avail.Storage	Storage Description
#1	50.50'	1,444 cf	Rain Garden (Irregular) Listed below (Recalc)

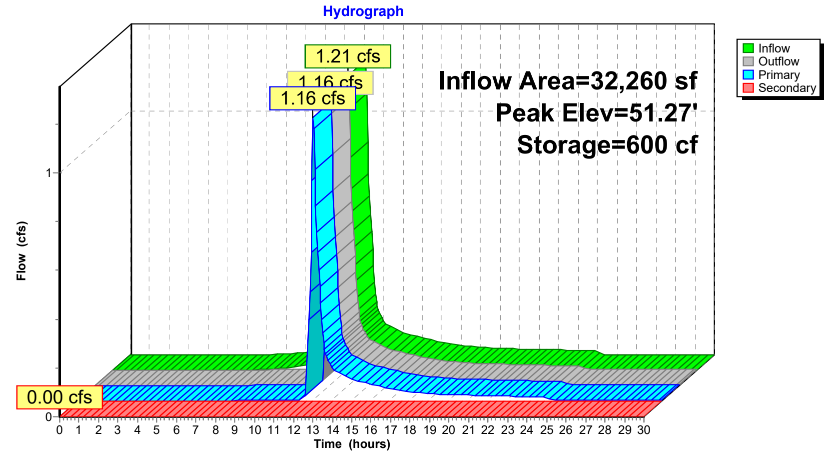
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
50.50	609	143.0	0	0	609
51.50	1,065	161.6	826	826	1,085
52.00	1,414	181.5	618	1,444	1,635

Device	Routing	Invert	Outlet Devices
#1	Primary	47.20'	12.0" Round Culvert L= 120.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.20' / 46.60' S= 0.0050 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	51.15'	2.0" x 2.0" Horiz. Orifice/Grate X 8.00 columns X 8 rows C= 0.600 in 24.0" x 24.0" Grate (44% open area) Limited to weir flow at low heads
#3	Secondary	51.50'	10.0' long x 18.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#4	Device 1	50.50'	0.270 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 47.00' Phase-In= 0.01'

```
Primary OutFlow  Max=1.13 cfs @ 12.12 hrs  HW=51.27'   (Free Discharge)
└─1=Culvert  (Passes 1.13 cfs of 5.07 cfs potential flow)
   ├─2=Orifice/Grate  (Weir Controls 1.12 cfs @ 1.14 fps)
   └─4=Exfiltration  ( Controls 0.01 cfs)

Secondary OutFlow  Max=0.00 cfs @ 0.00 hrs  HW=50.50'   (Free Discharge)
└─3=Broad-Crested Rectangular Weir   ( Controls 0.00 cfs)
```


Pond RG-2: Rain Garden-2 - Entrance



Summary for Pond SP-4: Study Point #4

[44] Hint: Outlet device #1 is below defined storage
[79] Warning: Submerged Pond RG-2 Primary device # 1 INLET by 1.15'

Inflow Area = 156,141 sf, 6.39% Impervious, Inflow Depth > 1.34" for 2-Year event
Inflow = 4.24 cfs @ 12.18 hrs, Volume= 17,378 cf
Outflow = 3.23 cfs @ 12.33 hrs, Volume= 17,378 cf, Atten= 24%, Lag= 8.8 min
Primary = 3.23 cfs @ 12.33 hrs, Volume= 17,378 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 48.35' @ 12.33 hrs Surf.Area= 2,639 sf Storage= 1,044 cf

Plug-Flow detention time= 1.6 min calculated for 17,349 cf (100% of inflow)
Center-of-Mass det. time= 1.6 min (862.7 - 861.1)

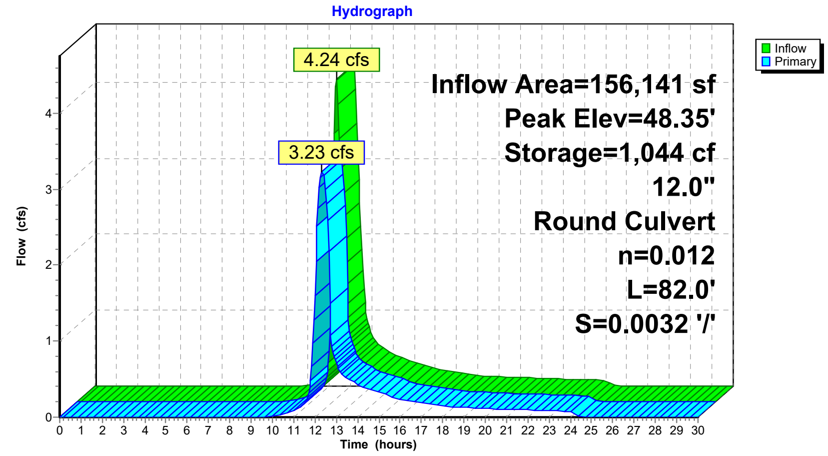
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	12.0" Round Culvert L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=3.22 cfs @ 12.33 hrs HW=48.35' (Free Discharge)
└1=Culvert (Barrel Controls 3.22 cfs @ 4.10 fps)

Pond SP-4: Study Point #4



Summary for Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

Inflow Area = 158,067 sf, 74.71% Impervious, Inflow Depth = 2.56" for 2-Year event
Inflow = 9.48 cfs @ 12.09 hrs, Volume= 33,782 cf
Outflow = 0.89 cfs @ 13.02 hrs, Volume= 33,782 cf, Atten= 91%, Lag= 56.0 min
Discarded = 0.72 cfs @ 11.35 hrs, Volume= 32,555 cf
Primary = 0.17 cfs @ 13.02 hrs, Volume= 1,227 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 102.82' @ 13.02 hrs Surf.Area= 12,920 sf Storage= 13,314 cf

Plug-Flow detention time= 139.4 min calculated for 33,725 cf (100% of inflow)
Center-of-Mass det. time= 139.2 min (917.2 - 778.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	101.00'	22,505 cf	76.00'W x 170.00'L x 9.00'H Field A 116,280 cf Overall - 60,017 cf Embedded = 56,263 cf x 40.0% Voids
#2A	101.50'	60,017 cf	CMP Round 96 x 56 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 56 Chambers in 7 Rows 74.00' Header x 50.27 sf x 1 = 3,719.6 cf Inside
		82,522 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	101.50'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 101.50' / 99.50' S= 0.0200 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Discarded	101.00'	2.410 in/hr Exfiltration over Surface area
#3	Device 1	102.50'	4.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	107.00'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.72 cfs @ 11.35 hrs HW=101.09' (Free Discharge)
└2=Exfiltration (Exfiltration Controls 0.72 cfs)

Primary OutFlow Max=0.17 cfs @ 13.02 hrs HW=102.82' (Free Discharge)
└1=Culvert (Passes 0.17 cfs of 2.71 cfs potential flow)
 ├3=Orifice/Grate (Orifice Controls 0.17 cfs @ 1.93 fps)
 └4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)
Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf
Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

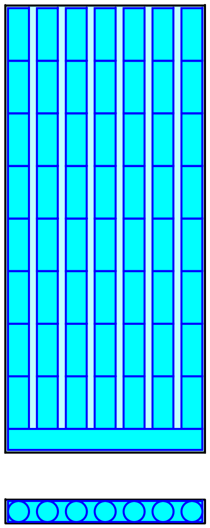
8 Chambers/Row x 20.00' Long +8.00' Header x 1 = 168.00' Row Length +12.0" End Stone x 2 = 170.00' Base Length
7 Rows x 96.0" Wide + 36.0" Spacing x 6 + 12.0" Side Stone x 2 = 76.00' Base Width
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

56 Chambers x 1,005.3 cf + 74.00' Header x 50.27 sf = 60,017.0 cf Chamber Storage

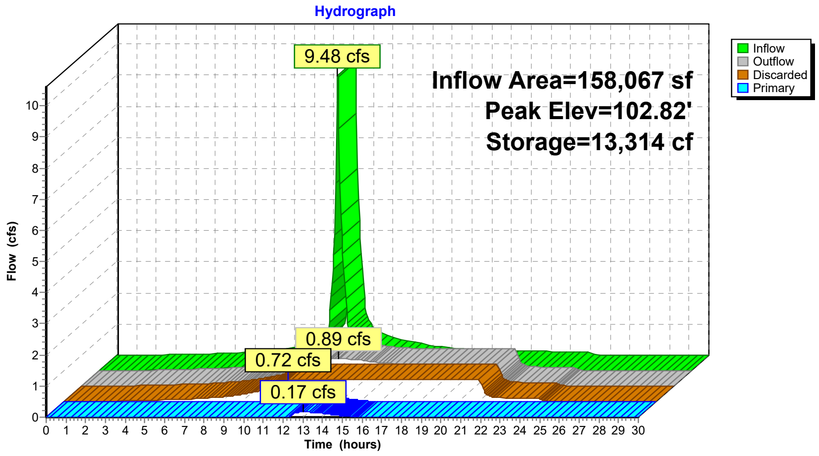
116,280.0 cf Field - 60,017.0 cf Chambers = 56,263.0 cf Stone x 40.0% Voids = 22,505.2 cf Stone Storage

Chamber Storage + Stone Storage = 82,522.2 cf = 1.894 af
Overall Storage Efficiency = 71.0%
Overall System Size = 170.00' x 76.00' x 9.00'

56 Chambers
4,306.7 cy Field
2,083.8 cy Stone



Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

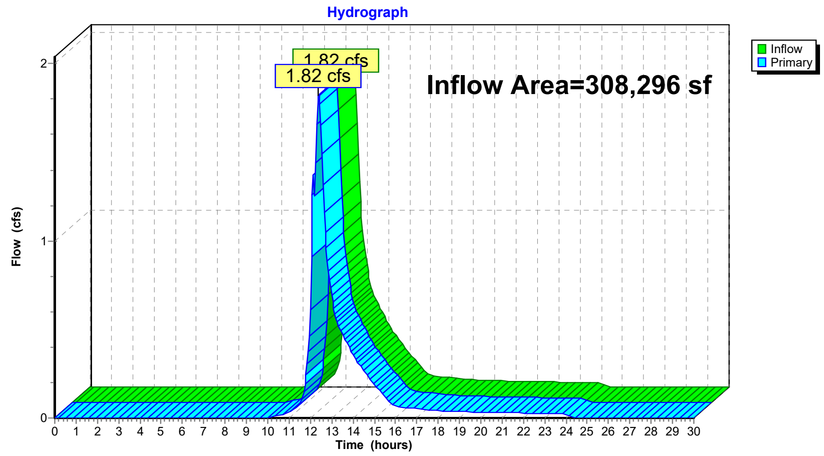


Summary for Link SP-1: Study Point #1

Inflow Area =	308,296 sf,	44.54% Impervious,	Inflow Depth = 0.36"	for 2-Year event
Inflow =	1.82 cfs @	12.39 hrs, Volume=	9,235 cf	
Primary =	1.82 cfs @	12.39 hrs, Volume=	9,235 cf, Atten= 0%, Lag= 0.0 min	

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

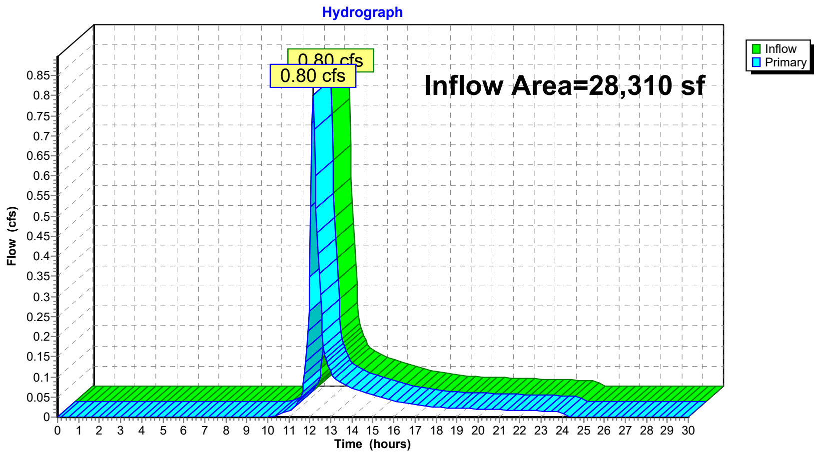


Summary for Link SP-2: Study Point #2

Inflow Area = 28,310 sf, 0.00% Impervious, Inflow Depth = 1.24" for 2-Year event
Inflow = 0.80 cfs @ 12.15 hrs, Volume= 2,926 cf
Primary = 0.80 cfs @ 12.15 hrs, Volume= 2,926 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

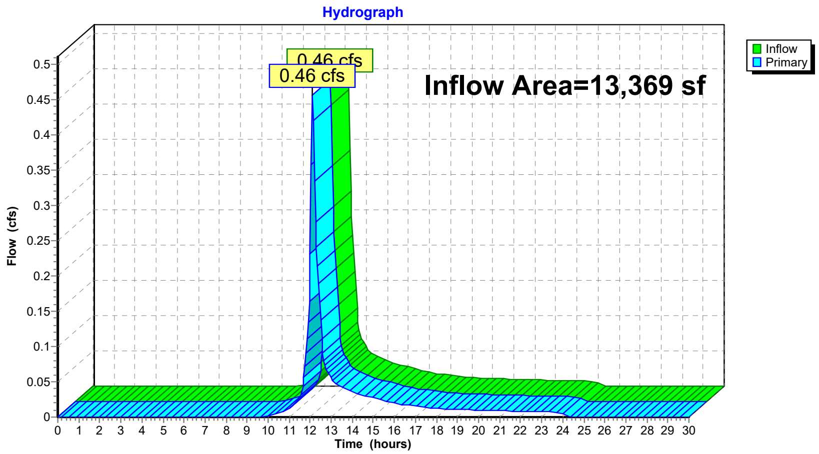


Summary for Link SP-3: Study Point #3

Inflow Area = 13,369 sf, 4.23% Impervious, Inflow Depth = 1.37" for 2-Year event
Inflow = 0.46 cfs @ 12.11 hrs, Volume= 1,523 cf
Primary = 0.46 cfs @ 12.11 hrs, Volume= 1,523 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North	Runoff Area=45,886 sf 0.00% Impervious Runoff Depth=2.61" Flow Length=148' Tc=9.7 min CN=78 Runoff=2.80 cfs 9,981 cf
Subcatchment P-10: Proposed Building Roof	Runoff Area=30,352 sf 100.00% Impervious Runoff Depth=4.64" Tc=6.0 min CN=98 Runoff=3.25 cfs 11,745 cf
Subcatchment P-11: South Courtyard	Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=4.64" Tc=6.0 min CN=98 Runoff=2.16 cfs 7,809 cf
Subcatchment P-12: Southeast Roof Area	Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=4.64" Tc=6.0 min CN=98 Runoff=2.92 cfs 10,546 cf
Subcatchment P-13: Main Parking Area	Runoff Area=18,475 sf 73.00% Impervious Runoff Depth=4.08" Tc=6.0 min CN=93 Runoff=1.87 cfs 6,282 cf
Subcatchment P-14: Southwest Lawn	Runoff Area=24,170 sf 21.35% Impervious Runoff Depth=3.16" Flow Length=245' Tc=13.3 min CN=84 Runoff=1.61 cfs 6,366 cf
Subcatchment P-15: Lawn/Fire Access	Runoff Area=43,949 sf 21.71% Impervious Runoff Depth=3.16" Tc=6.0 min CN=84 Runoff=3.64 cfs 11,576 cf
Subcatchment P-16: Entry Driveway	Runoff Area=12,275 sf 65.60% Impervious Runoff Depth=3.97" Tc=6.0 min CN=92 Runoff=1.22 cfs 4,063 cf
Subcatchment P-17: Bio-retenion/Rain Garden	Runoff Area=23,236 sf 0.00% Impervious Runoff Depth=2.19" Tc=6.0 min CN=73 Runoff=1.33 cfs 4,234 cf
Subcatchment P-2: Direct Flow to Wetlands "F"	Runoff Area=28,310 sf 0.00% Impervious Runoff Depth=2.52" Flow Length=230' Tc=9.7 min CN=77 Runoff=1.67 cfs 5,952 cf
Subcatchment P-3: Flow Southwest Off-Site	Runoff Area=13,369 sf 4.23% Impervious Runoff Depth=2.70" Flow Length=62' Slope=0.3000 '/' Tc=7.4 min CN=79 Runoff=0.91 cfs 3,007 cf
Subcatchment P-4: Flow Southeast to Wetlands "A"	Runoff Area=123,881 sf 0.67% Impervious Runoff Depth=2.61" Flow Length=186' Tc=14.0 min CN=78 Runoff=6.71 cfs 26,945 cf
Subcatchment P-5: Entrance Drive	Runoff Area=18,436 sf 46.85% Impervious Runoff Depth=3.56" Tc=6.0 min CN=88 Runoff=1.69 cfs 5,462 cf
Subcatchment P-6: Landcaped Slope/Walls	Runoff Area=13,824 sf 3.65% Impervious Runoff Depth=2.19" Flow Length=175' Tc=11.7 min UI Adjusted CN=73 Runoff=0.66 cfs 2,519 cf
Subcatchment P-7: Landscaped Slope	Runoff Area=24,883 sf 6.52% Impervious Runoff Depth=2.35" Tc=6.0 min CN=75 Runoff=1.54 cfs 4,878 cf
Subcatchment P-8: Cul-de-Sac/Garage Turn Around	Runoff Area=22,308 sf 74.44% Impervious Runoff Depth=4.08" Tc=6.0 min CN=93 Runoff=2.25 cfs 7,585 cf

Subcatchment P-9: North Courtyard/Green Roof	Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=3.36" Tc=6.0 min CN=86 Runoff=1.34 cfs 4,286 cf
Reach SWALE: Swale Abutting Entry Driveway	Avg. Flow Depth=0.32' Max Vel=1.57 fps Inflow=1.54 cfs 4,878 cf n=0.100 L=427.0' S=0.0714 '/' Capacity=6.48 cfs Outflow=1.35 cfs 4,878 cf
Pond 2P: New Rain Garden/Bioretention Area	Peak Elev=59.07' Storage=6,055 cf Inflow=7.52 cfs 34,056 cf Discarded=0.27 cfs 13,056 cf Primary=5.24 cfs 20,994 cf Secondary=0.00 cfs 0 cf Outflow=5.51 cfs 34,050 cf
Pond RG-2: Rain Garden-2 - Entrance	Peak Elev=51.34' Storage=662 cf Inflow=2.23 cfs 7,981 cf Primary=2.16 cfs 7,622 cf Secondary=0.00 cfs 0 cf Outflow=2.16 cfs 7,622 cf
Pond SP-4: Study Point #4	Peak Elev=49.09' Storage=5,053 cf Inflow=8.54 cfs 34,567 cf 12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=4.29 cfs 34,567 cf
Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)	Peak Elev=103.88' Storage=23,828 cf Inflow=15.01 cfs 54,618 cf Discarded=0.72 cfs 45,313 cf Primary=0.46 cfs 9,305 cf Outflow=1.18 cfs 54,618 cf
Link SP-1: Study Point #1	Inflow=7.93 cfs 30,975 cf Primary=7.93 cfs 30,975 cf
Link SP-2: Study Point #2	Inflow=1.67 cfs 5,952 cf Primary=1.67 cfs 5,952 cf
Link SP-3: Study Point #3	Inflow=0.91 cfs 3,007 cf Primary=0.91 cfs 3,007 cf

Total Runoff Area = 506,116 sf Runoff Volume = 133,235 cf Average Runoff Depth = 3.16"
70.79% Pervious = 358,265 sf 29.21% Impervious = 147,851 sf

Summary for Subcatchment P-1: Flow to Wetlands - North

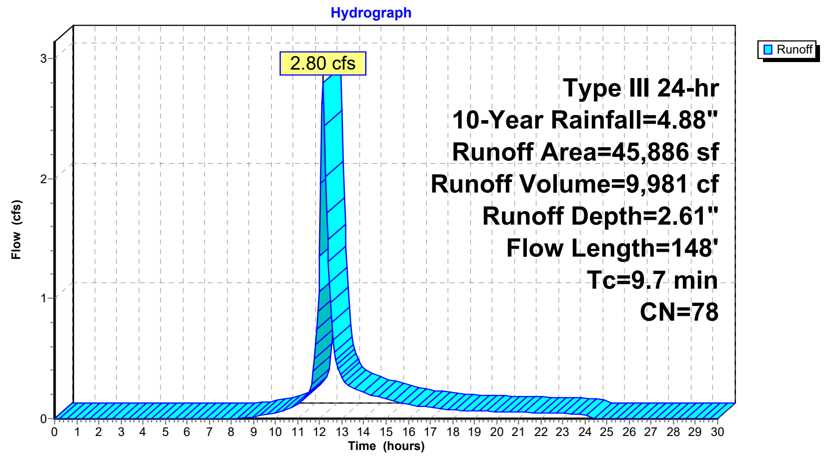
Runoff = 2.80 cfs @ 12.14 hrs, Volume= 9,981 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
9,993	80	>75% Grass cover, Good, HSG D
35,893	77	Woods, Good, HSG D
45,886	78	Weighted Average
45,886		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	50	0.2120	0.10		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
1.3	98	0.2620	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	148	Total			

Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

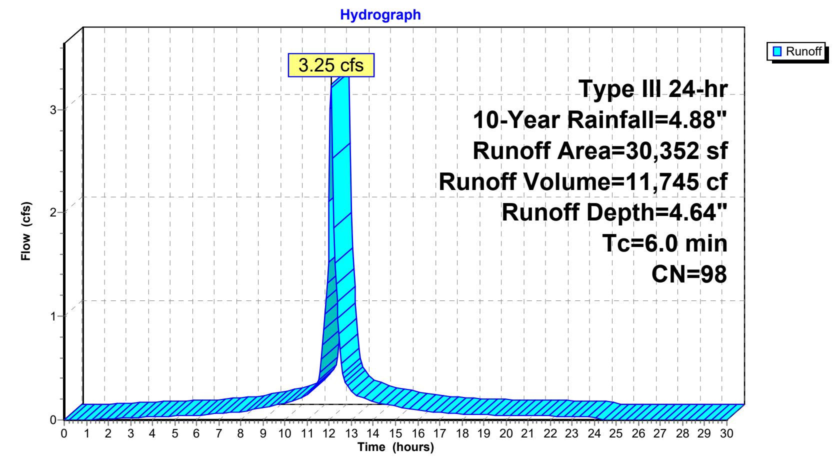
Runoff = 3.25 cfs @ 12.09 hrs, Volume= 11,745 cf, Depth= 4.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
30,352	98	Unconnected roofs, HSG D
30,352		100.00% Impervious Area
30,352		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

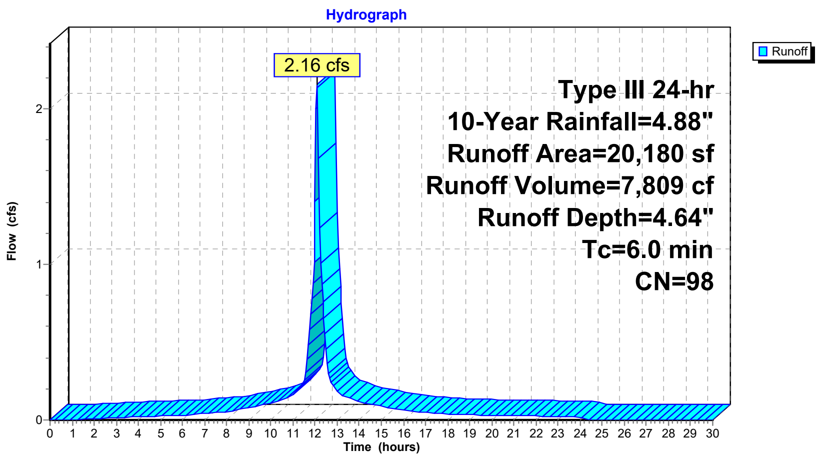
Runoff = 2.16 cfs @ 12.09 hrs, Volume= 7,809 cf, Depth= 4.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

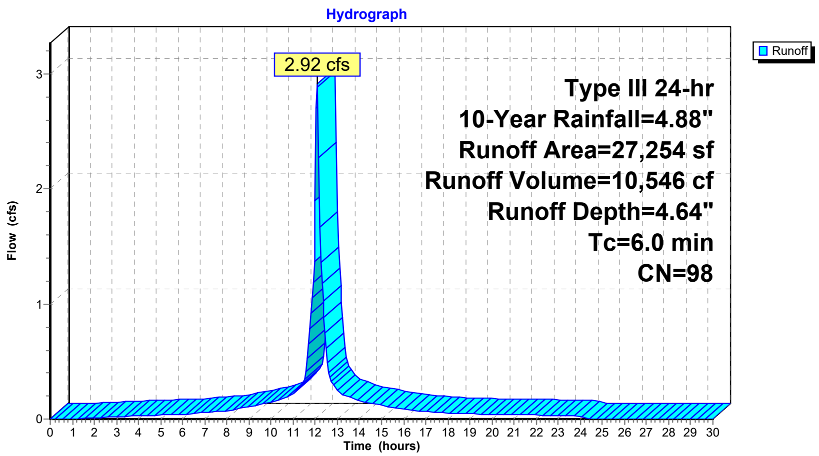
Runoff = 2.92 cfs @ 12.09 hrs, Volume= 10,546 cf, Depth= 4.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

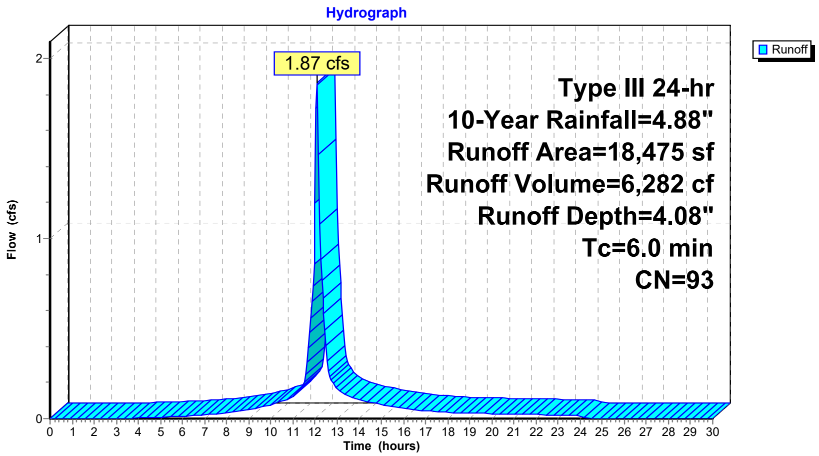
Runoff = 1.87 cfs @ 12.09 hrs, Volume= 6,282 cf, Depth= 4.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
13,486	98	Unconnected pavement, HSG D
4,989	80	>75% Grass cover, Good, HSG D
18,475	93	Weighted Average
4,989		27.00% Pervious Area
13,486		73.00% Impervious Area
13,486		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: Southwest Lawn

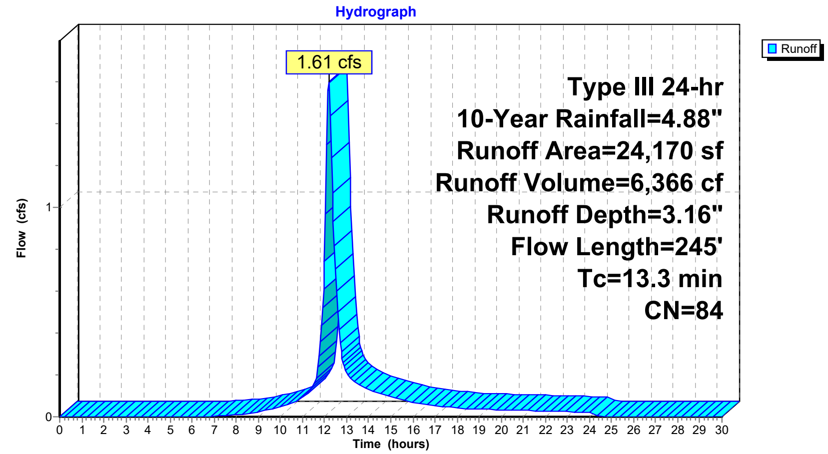
Runoff = 1.61 cfs @ 12.18 hrs, Volume= 6,366 cf, Depth= 3.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
5,161	98	Paved parking, HSG D
19,009	80	>75% Grass cover, Good, HSG D
24,170	84	Weighted Average
19,009		78.65% Pervious Area
5,161		21.35% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	50	0.0100	0.08		Sheet Flow, Grass: Dense n= 0.240 P2= 3.16"
1.9	80	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.5	115	0.0400	4.06		Shallow Concentrated Flow, Paved Kv= 20.3 fps
13.3	245	Total			

Subcatchment P-14: Southwest Lawn



Summary for Subcatchment P-15: Lawn/Fire Access

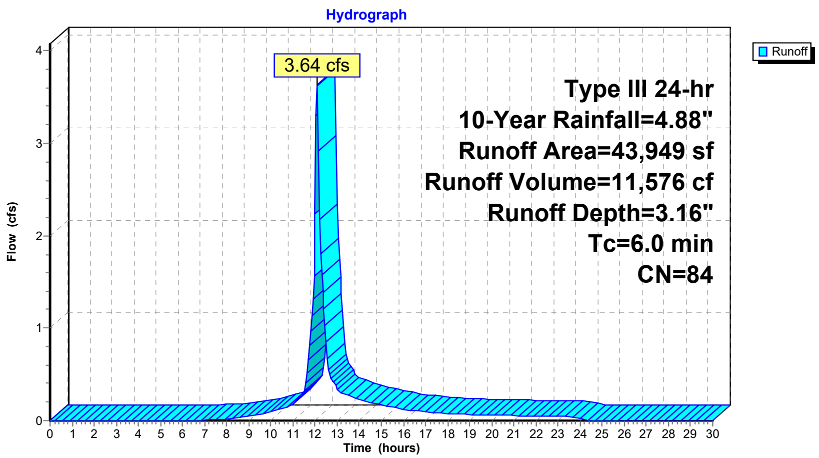
Runoff = 3.64 cfs @ 12.09 hrs, Volume= 11,576 cf, Depth= 3.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

	Area (sf)	CN	Description
	9,543	98	Paved parking, HSG D
*	3,854	80	GrassPave2, Good, HSG D
	30,552	80	>75% Grass cover, Good, HSG D
	43,949	84	Weighted Average
	34,406		78.29% Pervious Area
	9,543		21.71% Impervious Area

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

Subcatchment P-15: Lawn/Fire Access



Summary for Subcatchment P-16: Entry Driveway

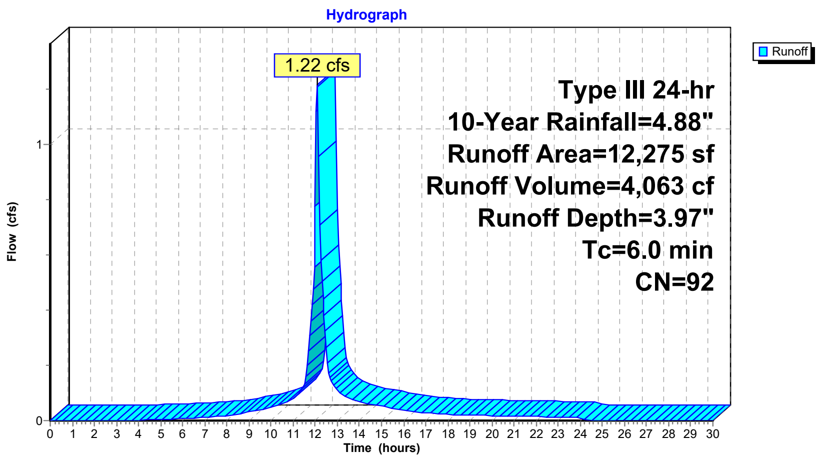
Runoff = 1.22 cfs @ 12.09 hrs, Volume= 4,063 cf, Depth= 3.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
8,053	98	Unconnected pavement, HSG D
4,222	80	>75% Grass cover, Good, HSG D
12,275	92	Weighted Average
4,222		34.40% Pervious Area
8,053		65.60% Impervious Area
8,053		100.00% Unconnected

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

Subcatchment P-16: Entry Driveway



Summary for Subcatchment P-17: Bio-retenion/Rain Garden

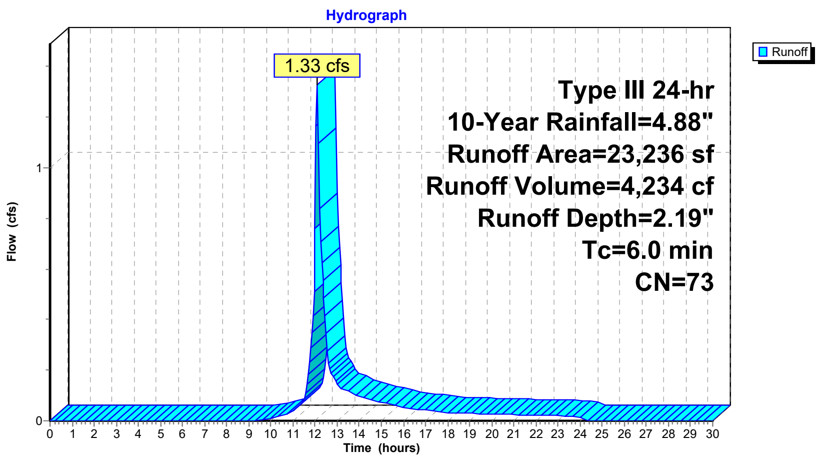
Runoff = 1.33 cfs @ 12.10 hrs, Volume= 4,234 cf, Depth= 2.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
23,236	73	Brush, Good, HSG D
0	77	Woods, Good, HSG D
23,236	73	Weighted Average
23,236		100.00% Pervious Area

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

Subcatchment P-17: Bio-retenion/Rain Garden



Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

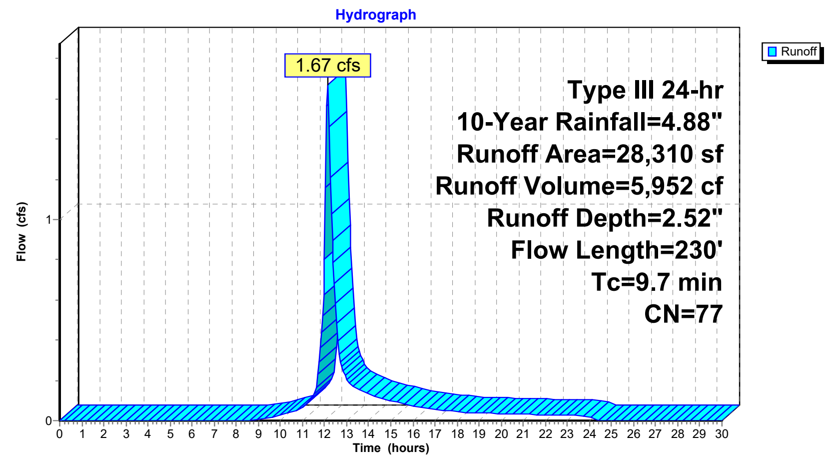
Runoff = 1.67 cfs @ 12.14 hrs, Volume= 5,952 cf, Depth= 2.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
0	80	>75% Grass cover, Good, HSG D
28,310	77	Woods, Good, HSG D
28,310	77	Weighted Average
28,310		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.2980	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.4	180	0.2580	1.27		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	230	Total			

Subcatchment P-2: Direct Flow to Wetlands "F"



Summary for Subcatchment P-3: Flow Southwest Off-Site

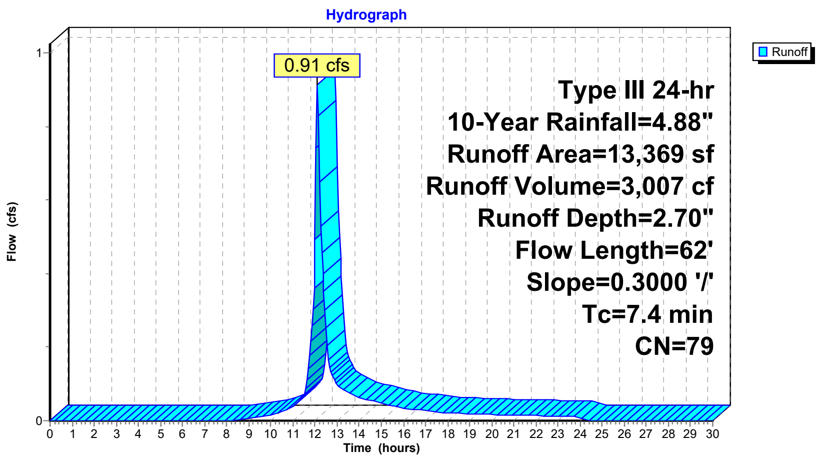
Runoff = 0.91 cfs @ 12.11 hrs, Volume= 3,007 cf, Depth= 2.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
6,978	80	>75% Grass cover, Good, HSG D
5,825	77	Woods, Good, HSG D
566	98	Unconnected pavement, HSG D
13,369	79	Weighted Average
12,803		95.77% Pervious Area
566		4.23% Impervious Area
566		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.3000	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
0.1	12	0.3000	1.37		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
7.4	62	Total			

Subcatchment P-3: Flow Southwest Off-Site



Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

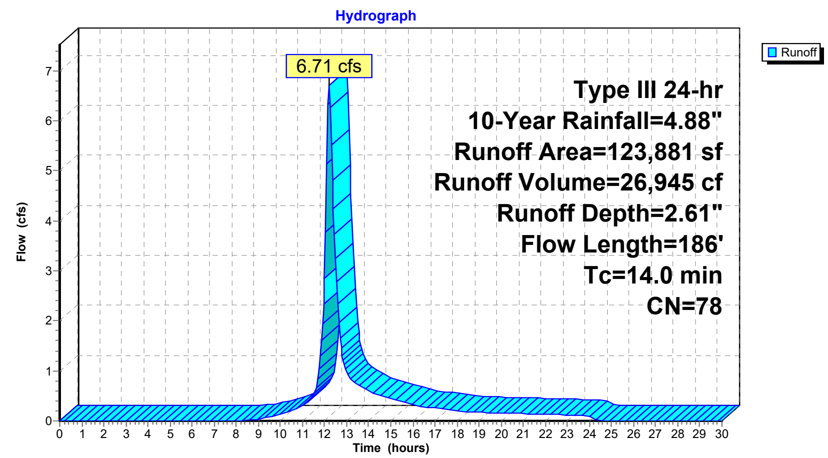
Runoff = 6.71 cfs @ 12.20 hrs, Volume= 26,945 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
90,423	77	Woods, Good, HSG D
32,630	80	>75% Grass cover, Good, HSG D
828	98	Unconnected pavement, HSG D
123,881	78	Weighted Average
123,053		99.33% Pervious Area
828		0.67% Impervious Area
828		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

Subcatchment P-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment P-5: Entrance Drive

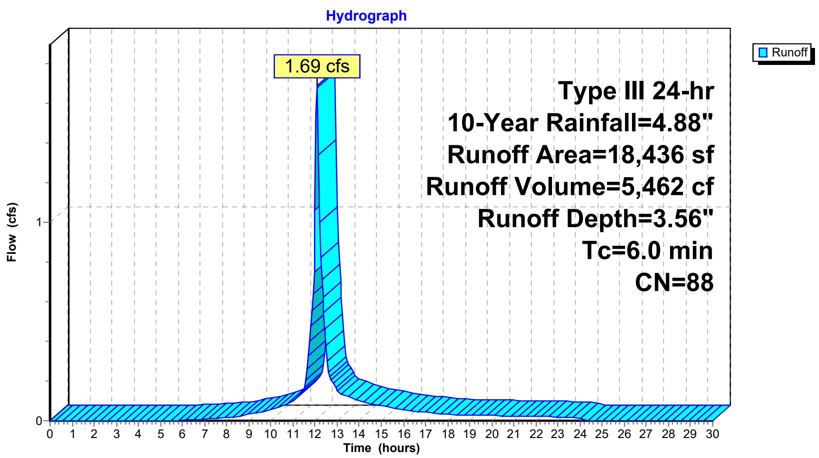
Runoff = 1.69 cfs @ 12.09 hrs, Volume= 5,462 cf, Depth= 3.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
8,637	98	Paved parking, HSG D
9,799	80	>75% Grass cover, Good, HSG D
18,436	88	Weighted Average
9,799		53.15% Pervious Area
8,637		46.85% Impervious Area

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

Subcatchment P-5: Entrance Drive



Summary for Subcatchment P-6: Landcaped Slope/Walls

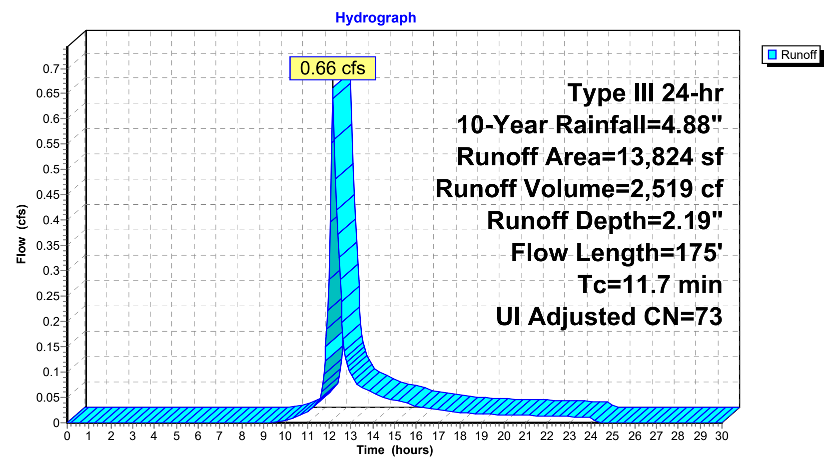
Runoff = 0.66 cfs @ 12.17 hrs, Volume= 2,519 cf, Depth= 2.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Adj	Description
13,319	73		Brush, Good, HSG D
505	98		Unconnected pavement, HSG D
13,824	74	73	Weighted Average, UI Adjusted
13,319			96.35% Pervious Area
505			3.65% Impervious Area
505			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.8	50	0.0300	0.08		Sheet Flow, Grass: Bermuda n= 0.410 P2= 3.16"
0.9	125	0.0600	2.40	6.61	Trap/Vee/Rect Channel Flow, Bot.W=4.00' D=0.50' Z= 3.0 '/' Top.W=7.00' n= 0.080 Earth, long dense weeds
11.7	175	Total			

Subcatchment P-6: Landcaped Slope/Walls



Summary for Subcatchment P-7: Landscaped Slope

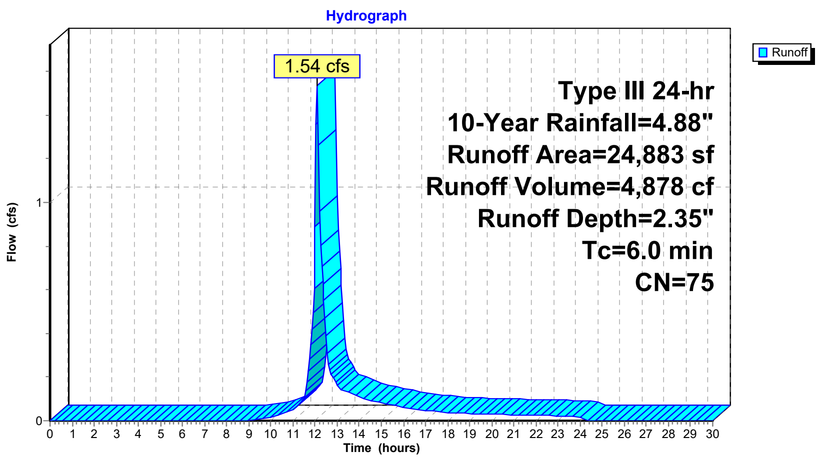
Runoff = 1.54 cfs @ 12.09 hrs, Volume= 4,878 cf, Depth= 2.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
1,622	98	Paved parking, HSG D
23,261	73	Brush, Good, HSG D
24,883	75	Weighted Average
23,261		93.48% Pervious Area
1,622		6.52% Impervious Area

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

Subcatchment P-7: Landscaped Slope



Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

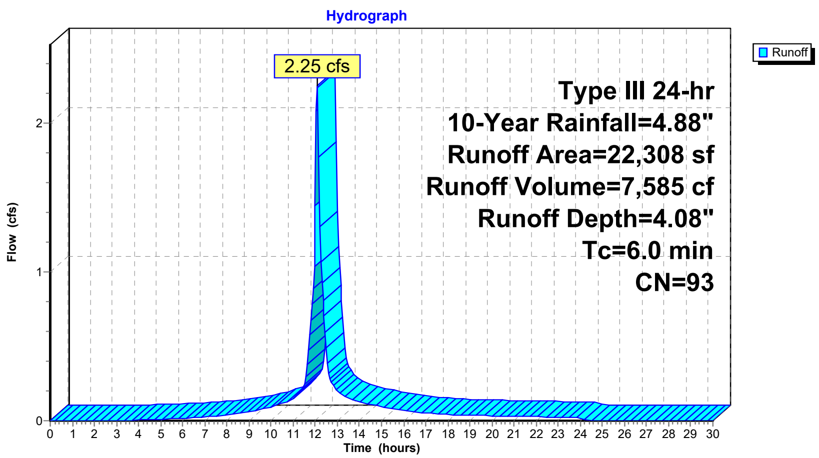
Runoff = 2.25 cfs @ 12.09 hrs, Volume= 7,585 cf, Depth= 4.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
16,606	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,308	93	Weighted Average
5,702		25.56% Pervious Area
16,606		74.44% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

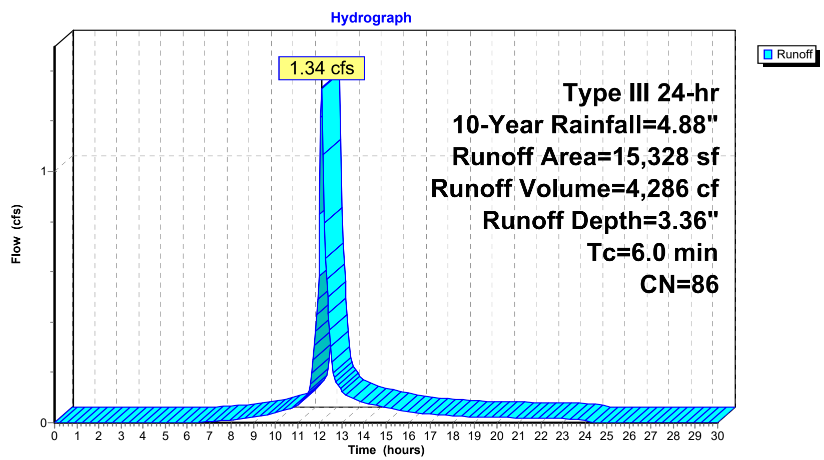
Runoff = 1.34 cfs @ 12.09 hrs, Volume= 4,286 cf, Depth= 3.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



Summary for Reach SWALE: Swale Abutting Entry Driveway

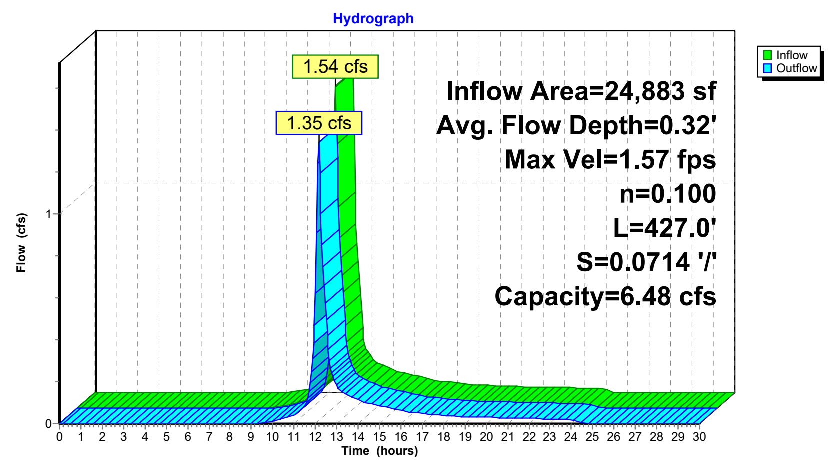
Inflow Area = 24,883 sf, 6.52% Impervious, Inflow Depth = 2.35" for 10-Year event
Inflow = 1.54 cfs @ 12.09 hrs, Volume= 4,878 cf
Outflow = 1.35 cfs @ 12.15 hrs, Volume= 4,878 cf, Atten= 13%, Lag= 3.0 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.57 fps, Min. Travel Time= 4.5 min
Avg. Velocity = 0.43 fps, Avg. Travel Time= 16.5 min

Peak Storage= 366 cf @ 12.14 hrs
Average Depth at Peak Storage= 0.32'
Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 6.48 cfs

2.00' x 0.75' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 2.0 '/' Top Width= 5.00'
Length= 427.0' Slope= 0.0714 '/'
Inlet Invert= 98.00', Outlet Invert= 67.50'

Reach SWALE: Swale Abutting Entry Driveway



Summary for Pond 2P: New Rain Garden/Bioretention Area

Inflow Area = 262,410 sf, 52.33% Impervious, Inflow Depth = 1.56" for 10-Year event
Inflow = 7.52 cfs @ 12.10 hrs, Volume= 34,056 cf
Outflow = 5.51 cfs @ 12.20 hrs, Volume= 34,050 cf, Atten= 27%, Lag= 5.8 min
Discarded = 0.27 cfs @ 12.20 hrs, Volume= 13,056 cf
Primary = 5.24 cfs @ 12.20 hrs, Volume= 20,994 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 59.07' @ 12.20 hrs Surf.Area= 4,863 sf Storage= 6,055 cf

Plug-Flow detention time= 96.0 min calculated for 34,050 cf (100% of inflow)
Center-of-Mass det. time= 95.9 min (940.8 - 844.9)

Volume	Invert	Avail.Storage	Storage Description
#1	57.00'	15,686 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
57.00	1,407	540.0	0	0	1,407
58.00	2,750	481.0	2,041	2,041	6,228
60.00	7,194	732.0	9,595	11,636	30,487
60.50	9,042	748.0	4,050	15,686	32,407

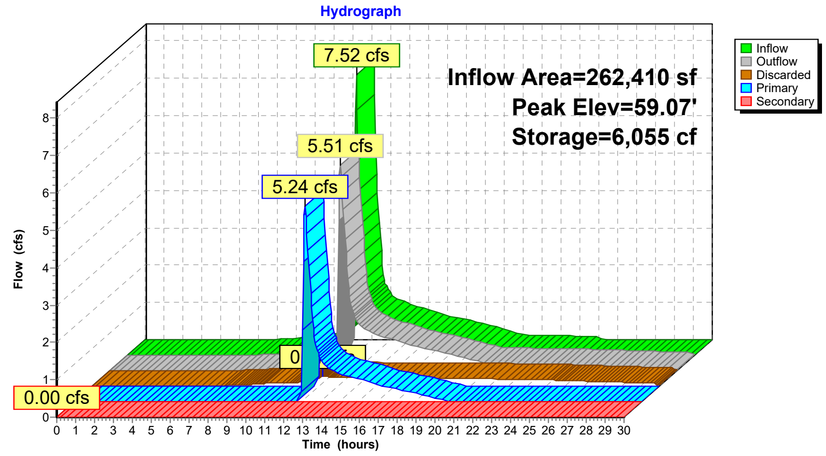
Device	Routing	Invert	Outlet Devices
#1	Primary	57.00'	24.0" Round Culvert L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 57.00' / 56.00' S= 0.0500 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 3.14 sf
#2	Device 1	58.50'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	57.00'	2.410 in/hr Exfiltration over Surface area
#4	Secondary	59.55'	10.0' long x 12.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Discarded OutFlow Max=0.27 cfs @ 12.20 hrs HW=59.07' (Free Discharge)
└3=Exfiltration (Exfiltration Controls 0.27 cfs)

Primary OutFlow Max=5.22 cfs @ 12.20 hrs HW=59.07' (Free Discharge)
└1=Culvert (Passes 5.22 cfs of 12.34 cfs potential flow)
 └2=Broad-Crested Rectangular Weir (Weir Controls 5.22 cfs @ 2.30 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=57.00' (Free Discharge)
└4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 2P: New Rain Garden/Bioretention Area



Summary for Pond RG-2: Rain Garden-2 - Entrance

Inflow Area = 32,260 sf, 28.34% Impervious, Inflow Depth = 2.97" for 10-Year event
Inflow = 2.23 cfs @ 12.10 hrs, Volume= 7,981 cf
Outflow = 2.16 cfs @ 12.12 hrs, Volume= 7,622 cf, Atten= 3%, Lag= 0.9 min
Primary = 2.16 cfs @ 12.12 hrs, Volume= 7,622 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 51.34' @ 12.12 hrs Surf.Area= 983 sf Storage= 662 cf

Plug-Flow detention time= 55.2 min calculated for 7,609 cf (95% of inflow)
Center-of-Mass det. time= 30.8 min (844.6 - 813.8)

Volume	Invert	Avail.Storage	Storage Description
#1	50.50'	1,444 cf	Rain Garden (Irregular) Listed below (Recalc)

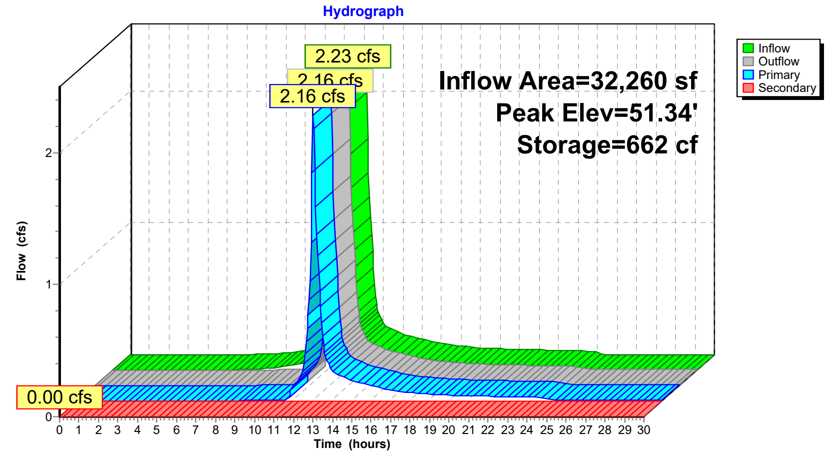
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
50.50	609	143.0	0	0	609
51.50	1,065	161.6	826	826	1,085
52.00	1,414	181.5	618	1,444	1,635

Device	Routing	Invert	Outlet Devices
#1	Primary	47.20'	12.0" Round Culvert L= 120.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.20' / 46.60' S= 0.0050 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	51.15'	2.0" x 2.0" Horiz. Orifice/Grate X 8.00 columns X 8 rows C= 0.600 in 24.0" x 24.0" Grate (44% open area) Limited to weir flow at low heads
#3	Secondary	51.50'	10.0' long x 18.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#4	Device 1	50.50'	0.270 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 47.00' Phase-In= 0.01'

Primary OutFlow Max=2.11 cfs @ 12.12 hrs HW=51.34' (Free Discharge)
└1=Culvert (Passes 2.11 cfs of 5.12 cfs potential flow)
 ├2=Orifice/Grate (Weir Controls 2.10 cfs @ 1.41 fps)
 └4=Exfiltration (Controls 0.01 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=50.50' (Free Discharge)
└3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond RG-2: Rain Garden-2 - Entrance



Summary for Pond SP-4: Study Point #4

[44] Hint: Outlet device #1 is below defined storage
[79] Warning: Submerged Pond RG-2 Primary device # 1 INLET by 1.89'

Inflow Area = 156,141 sf, 6.39% Impervious, Inflow Depth > 2.66" for 10-Year event
Inflow = 8.54 cfs @ 12.18 hrs, Volume= 34,567 cf
Outflow = 4.29 cfs @ 12.47 hrs, Volume= 34,567 cf, Atten= 50%, Lag= 17.7 min
Primary = 4.29 cfs @ 12.47 hrs, Volume= 34,567 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 49.09' @ 12.47 hrs Surf.Area= 8,247 sf Storage= 5,053 cf

Plug-Flow detention time= 6.5 min calculated for 34,510 cf (100% of inflow)
Center-of-Mass det. time= 6.5 min (844.1 - 837.6)

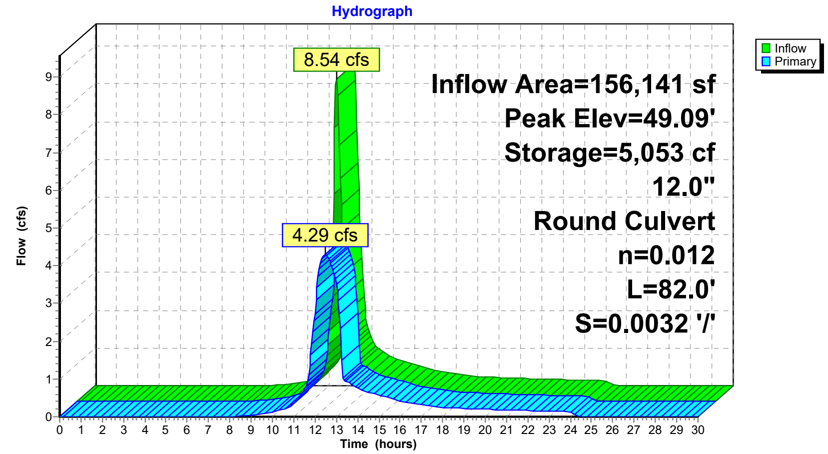
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	12.0" Round Culvert L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=4.29 cfs @ 12.47 hrs HW=49.09' (Free Discharge)
└1=Culvert (Barrel Controls 4.29 cfs @ 5.46 fps)

Pond SP-4: Study Point #4



Summary for Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

Inflow Area = 158,067 sf, 74.71% Impervious, Inflow Depth = 4.15" for 10-Year event
Inflow = 15.01 cfs @ 12.09 hrs, Volume= 54,618 cf
Outflow = 1.18 cfs @ 13.28 hrs, Volume= 54,618 cf, Atten= 92%, Lag= 71.4 min
Discarded = 0.72 cfs @ 10.40 hrs, Volume= 45,313 cf
Primary = 0.46 cfs @ 13.28 hrs, Volume= 9,305 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 103.88' @ 13.28 hrs Surf.Area= 12,920 sf Storage= 23,828 cf

Plug-Flow detention time= 202.1 min calculated for 54,527 cf (100% of inflow)
Center-of-Mass det. time= 201.9 min (970.7 - 768.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	101.00'	22,505 cf	76.00'W x 170.00'L x 9.00'H Field A 116,280 cf Overall - 60,017 cf Embedded = 56,263 cf x 40.0% Voids
#2A	101.50'	60,017 cf	CMP Round 96 x 56 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 56 Chambers in 7 Rows 74.00' Header x 50.27 sf x 1 = 3,719.6 cf Inside
		82,522 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	101.50'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 101.50' / 99.50' S= 0.0200 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Discarded	101.00'	2.410 in/hr Exfiltration over Surface area
#3	Device 1	102.50'	4.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	107.00'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.72 cfs @ 10.40 hrs HW=101.09' (Free Discharge)
└2=Exfiltration (Exfiltration Controls 0.72 cfs)

Primary OutFlow Max=0.46 cfs @ 13.28 hrs HW=103.88' (Free Discharge)
└1=Culvert (Passes 0.46 cfs of 4.09 cfs potential flow)
  ├3=Orifice/Grate (Orifice Controls 0.46 cfs @ 5.30 fps)
  └4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)
Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf
Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

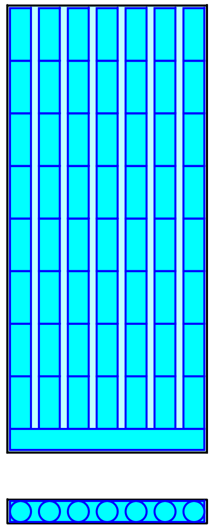
8 Chambers/Row x 20.00' Long +8.00' Header x 1 = 168.00' Row Length +12.0" End Stone x 2 = 170.00' Base Length
7 Rows x 96.0" Wide + 36.0" Spacing x 6 + 12.0" Side Stone x 2 = 76.00' Base Width
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

56 Chambers x 1,005.3 cf + 74.00' Header x 50.27 sf = 60,017.0 cf Chamber Storage

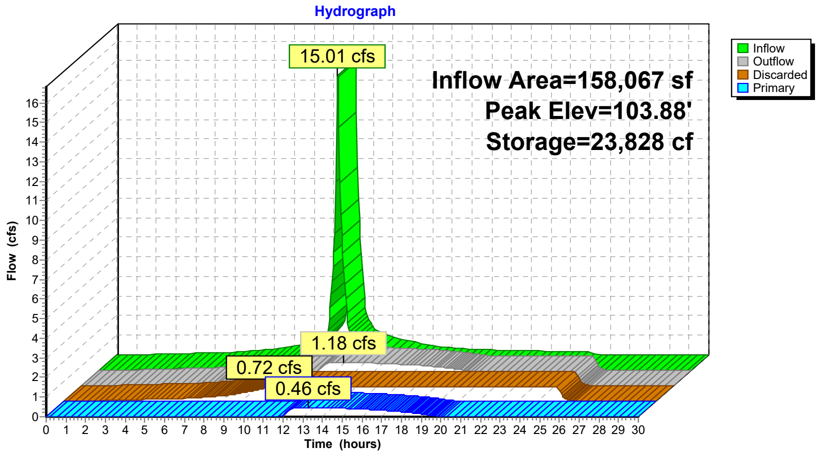
116,280.0 cf Field - 60,017.0 cf Chambers = 56,263.0 cf Stone x 40.0% Voids = 22,505.2 cf Stone Storage

Chamber Storage + Stone Storage = 82,522.2 cf = 1.894 af
Overall Storage Efficiency = 71.0%
Overall System Size = 170.00' x 76.00' x 9.00'

56 Chambers
4,306.7 cy Field
2,083.8 cy Stone



Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

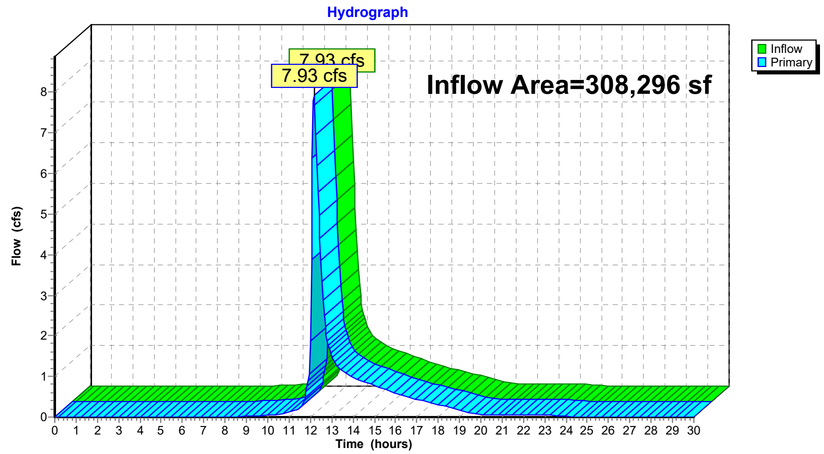


Summary for Link SP-1: Study Point #1

Inflow Area = 308,296 sf, 44.54% Impervious, Inflow Depth = 1.21" for 10-Year event
Inflow = 7.93 cfs @ 12.17 hrs, Volume= 30,975 cf
Primary = 7.93 cfs @ 12.17 hrs, Volume= 30,975 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

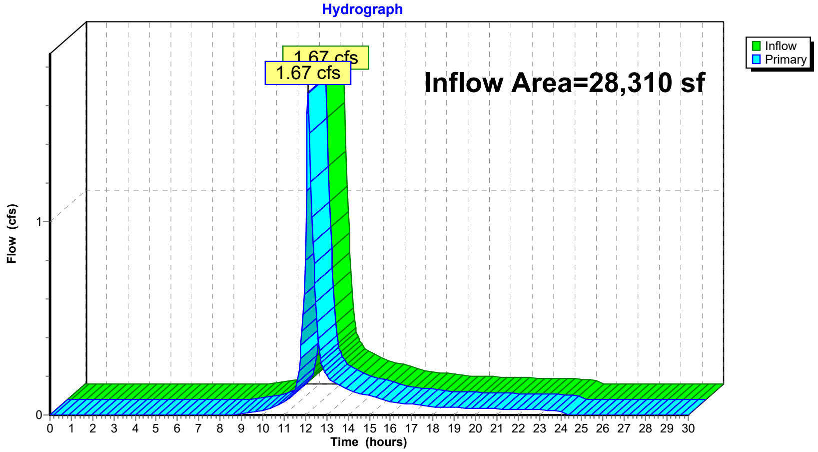


Summary for Link SP-2: Study Point #2

Inflow Area = 28,310 sf, 0.00% Impervious, Inflow Depth = 2.52" for 10-Year event
Inflow = 1.67 cfs @ 12.14 hrs, Volume= 5,952 cf
Primary = 1.67 cfs @ 12.14 hrs, Volume= 5,952 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

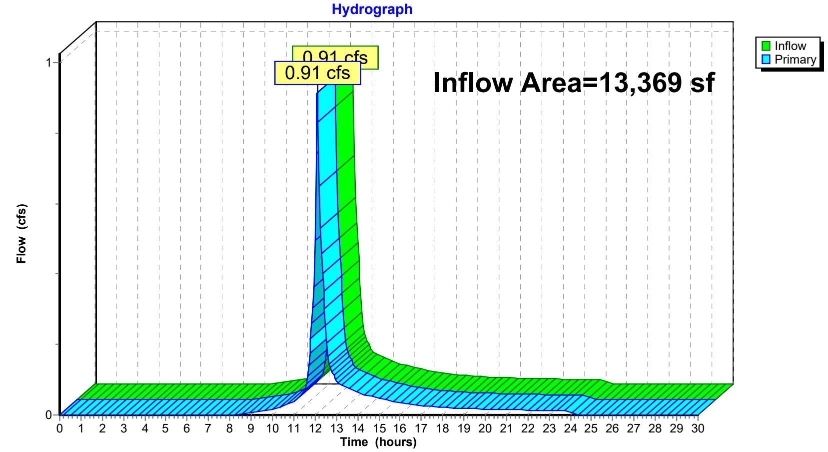


Summary for Link SP-3: Study Point #3

Inflow Area = 13,369 sf, 4.23% Impervious, Inflow Depth = 2.70" for 10-Year event
Inflow = 0.91 cfs @ 12.11 hrs, Volume= 3,007 cf
Primary = 0.91 cfs @ 12.11 hrs, Volume= 3,007 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North
Runoff Area=45,886 sf 0.00% Impervious Runoff Depth=3.73"
Flow Length=148' Tc=9.7 min CN=78 Runoff=4.00 cfs 14,261 cf

Subcatchment P-10: Proposed Building Roof
Runoff Area=30,352 sf 100.00% Impervious Runoff Depth=5.93"
Tc=6.0 min CN=98 Runoff=4.11 cfs 15,003 cf

Subcatchment P-11: South Courtyard
Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=5.93"
Tc=6.0 min CN=98 Runoff=2.74 cfs 9,975 cf

Subcatchment P-12: Southeast Roof Area
Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=5.93"
Tc=6.0 min CN=98 Runoff=3.69 cfs 13,472 cf

Subcatchment P-13: Main Parking Area
Runoff Area=18,475 sf 73.00% Impervious Runoff Depth=5.35"
Tc=6.0 min CN=93 Runoff=2.41 cfs 8,237 cf

Subcatchment P-14: Southwest Lawn
Runoff Area=24,170 sf 21.35% Impervious Runoff Depth=4.36"
Flow Length=245' Tc=13.3 min CN=84 Runoff=2.19 cfs 8,773 cf

Subcatchment P-15: Lawn/Fire Access
Runoff Area=43,949 sf 21.71% Impervious Runoff Depth=4.36"
Tc=6.0 min CN=84 Runoff=4.96 cfs 15,953 cf

Subcatchment P-16: Entry Driveway
Runoff Area=12,275 sf 65.60% Impervious Runoff Depth=5.24"
Tc=6.0 min CN=92 Runoff=1.58 cfs 5,357 cf

Subcatchment P-17: Bio-retenion/Rain Garden
Runoff Area=23,236 sf 0.00% Impervious Runoff Depth=3.23"
Tc=6.0 min CN=73 Runoff=1.98 cfs 6,255 cf

Subcatchment P-2: Direct Flow to Wetlands "F"
Runoff Area=28,310 sf 0.00% Impervious Runoff Depth=3.63"
Flow Length=230' Tc=9.7 min CN=77 Runoff=2.40 cfs 8,559 cf

Subcatchment P-3: Flow Southwest Off-Site
Runoff Area=13,369 sf 4.23% Impervious Runoff Depth=3.83"
Flow Length=62' Slope=0.3000 '/' Tc=7.4 min CN=79 Runoff=1.29 cfs 4,269 cf

Subcatchment P-4: Flow Southeast to Wetlands "A"
Runoff Area=123,881 sf 0.67% Impervious Runoff Depth=3.73"
Flow Length=186' Tc=14.0 min CN=78 Runoff=9.59 cfs 38,501 cf

Subcatchment P-5: Entrance Drive
Runoff Area=18,436 sf 46.85% Impervious Runoff Depth=4.79"
Tc=6.0 min CN=88 Runoff=2.24 cfs 7,359 cf

Subcatchment P-6: Landcaped Slope/Walls
Runoff Area=13,824 sf 3.65% Impervious Runoff Depth=3.23"
Flow Length=175' Tc=11.7 min UI Adjusted CN=73 Runoff=0.99 cfs 3,721 cf

Subcatchment P-7: Landscaped Slope
Runoff Area=24,883 sf 6.52% Impervious Runoff Depth=3.43"
Tc=6.0 min CN=75 Runoff=2.25 cfs 7,107 cf

Subcatchment P-8: Cul-de-Sac/Garage Turn Around
Runoff Area=22,308 sf 74.44% Impervious Runoff Depth=5.35"
Tc=6.0 min CN=93 Runoff=2.91 cfs 9,946 cf

Subcatchment P-9: North Courtyard/Green Roof
Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=4.57"
Tc=6.0 min CN=86 Runoff=1.80 cfs 5,839 cf

Reach SWALE: Swale Abutting Entry Driveway
Avg. Flow Depth=0.40' Max Vel=1.77 fps Inflow=2.25 cfs 7,107 cf
n=0.100 L=427.0' S=0.0714 '/' Capacity=6.48 cfs Outflow=2.00 cfs 7,107 cf

Pond 2P: New Rain Garden/Bioretention Area
Peak Elev=59.25' Storage=6,993 cf Inflow=10.71 cfs 52,059 cf
Discarded=0.30 cfs 14,627 cf Primary=8.49 cfs 37,053 cf Secondary=0.00 cfs 0 cf Outflow=8.79 cfs 51,680 cf

Pond RG-2: Rain Garden-2 - Entrance
Peak Elev=51.38' Storage=707 cf Inflow=3.07 cfs 11,080 cf
Primary=2.98 cfs 10,721 cf Secondary=0.00 cfs 0 cf Outflow=2.98 cfs 10,721 cf

Pond SP-4: Study Point #4
Peak Elev=49.59' Storage=9,621 cf Inflow=12.11 cfs 49,222 cf
12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=4.87 cfs 49,222 cf

Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)
Peak Elev=104.78' Storage=33,426 cf Inflow=19.37 cfs 71,246 cf
Discarded=0.72 cfs 53,859 cf Primary=0.61 cfs 17,388 cf Outflow=1.33 cfs 71,246 cf

Link SP-1: Study Point #1
Inflow=12.43 cfs 51,314 cf
Primary=12.43 cfs 51,314 cf

Link SP-2: Study Point #2
Inflow=2.40 cfs 8,559 cf
Primary=2.40 cfs 8,559 cf

Link SP-3: Study Point #3
Inflow=1.29 cfs 4,269 cf
Primary=1.29 cfs 4,269 cf

Total Runoff Area = 506,116 sf Runoff Volume = 182,587 cf Average Runoff Depth = 4.33"
70.79% Pervious = 358,265 sf 29.21% Impervious = 147,851 sf

Summary for Subcatchment P-1: Flow to Wetlands - North

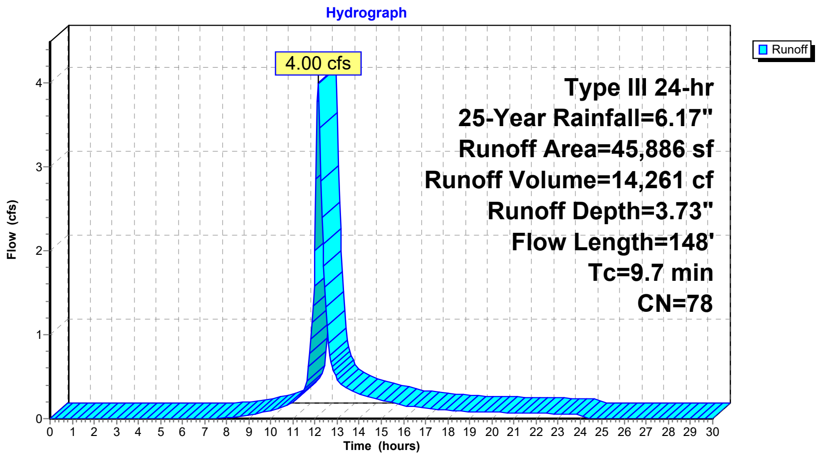
Runoff = 4.00 cfs @ 12.14 hrs, Volume= 14,261 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
9,993	80	>75% Grass cover, Good, HSG D
35,893	77	Woods, Good, HSG D
45,886	78	Weighted Average
45,886		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	50	0.2120	0.10		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
1.3	98	0.2620	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	148	Total			

Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

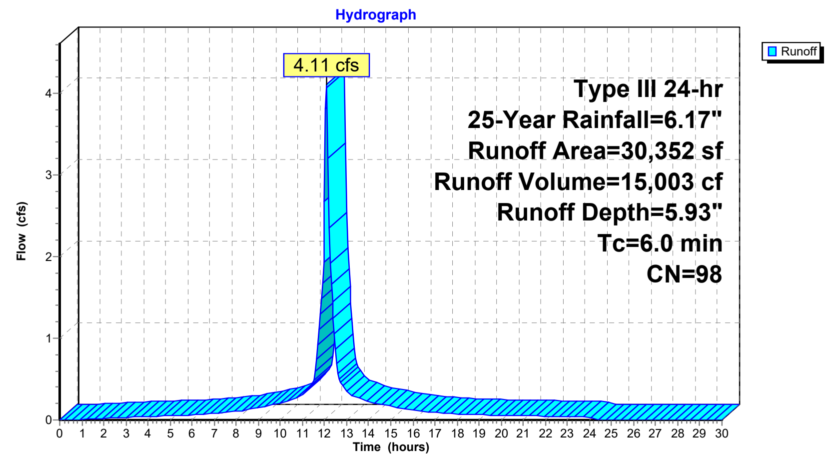
Runoff = 4.11 cfs @ 12.09 hrs, Volume= 15,003 cf, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
30,352	98	Unconnected roofs, HSG D
30,352		100.00% Impervious Area
30,352		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

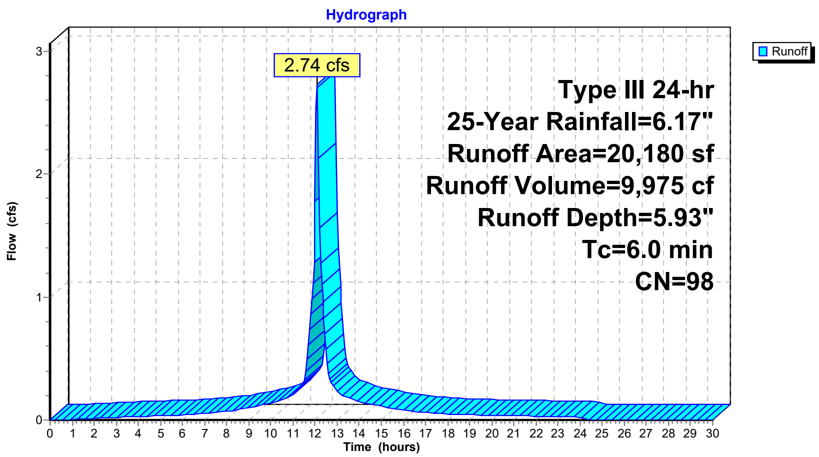
Runoff = 2.74 cfs @ 12.09 hrs, Volume= 9,975 cf, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

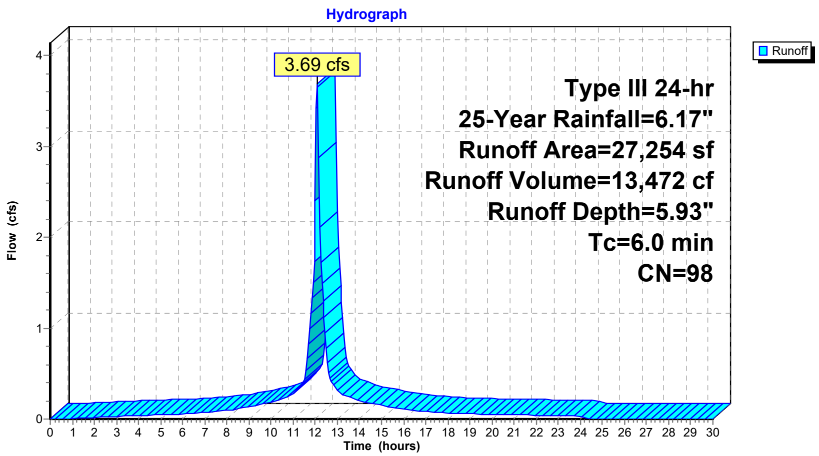
Runoff = 3.69 cfs @ 12.09 hrs, Volume= 13,472 cf, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

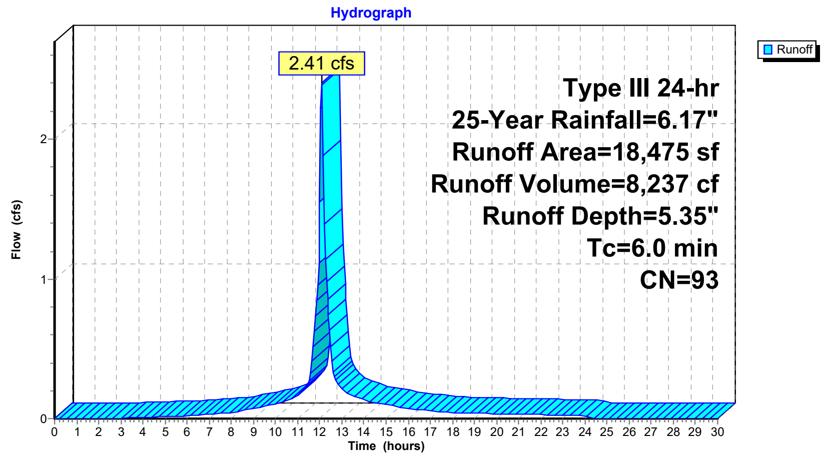
Runoff = 2.41 cfs @ 12.09 hrs, Volume= 8,237 cf, Depth= 5.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
13,486	98	Unconnected pavement, HSG D
4,989	80	>75% Grass cover, Good, HSG D
18,475	93	Weighted Average
4,989		27.00% Pervious Area
13,486		73.00% Impervious Area
13,486		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: Southwest Lawn

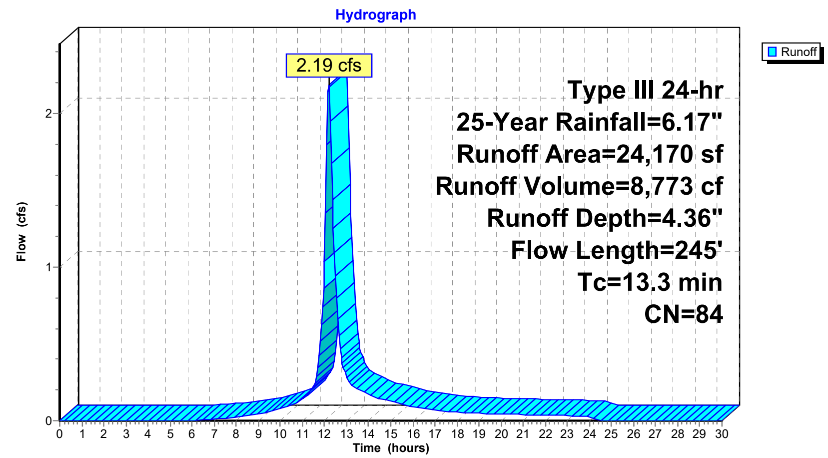
Runoff = 2.19 cfs @ 12.18 hrs, Volume= 8,773 cf, Depth= 4.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
5,161	98	Paved parking, HSG D
19,009	80	>75% Grass cover, Good, HSG D
24,170	84	Weighted Average
19,009		78.65% Pervious Area
5,161		21.35% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	50	0.0100	0.08		Sheet Flow, Grass: Dense n= 0.240 P2= 3.16"
1.9	80	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.5	115	0.0400	4.06		Shallow Concentrated Flow, Paved Kv= 20.3 fps
13.3	245	Total			

Subcatchment P-14: Southwest Lawn



Summary for Subcatchment P-15: Lawn/Fire Access

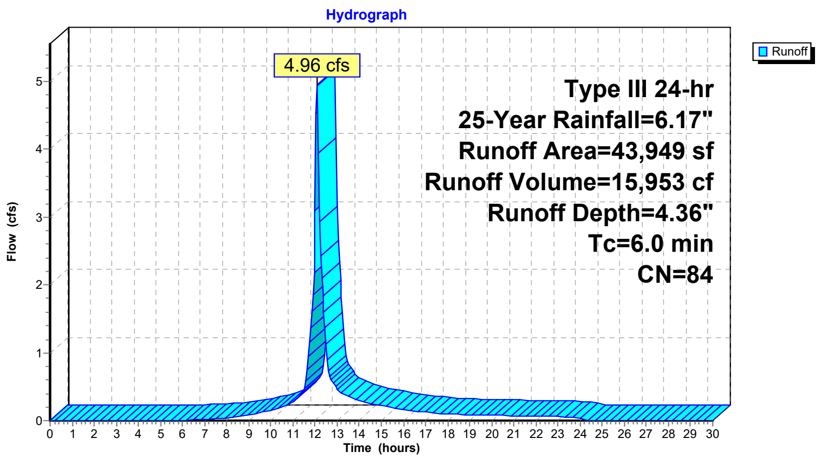
Runoff = 4.96 cfs @ 12.09 hrs, Volume= 15,953 cf, Depth= 4.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

	Area (sf)	CN	Description
	9,543	98	Paved parking, HSG D
*	3,854	80	GrassPave2, Good, HSG D
	30,552	80	>75% Grass cover, Good, HSG D
	43,949	84	Weighted Average
	34,406		78.29% Pervious Area
	9,543		21.71% Impervious Area

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

Subcatchment P-15: Lawn/Fire Access



Summary for Subcatchment P-16: Entry Driveway

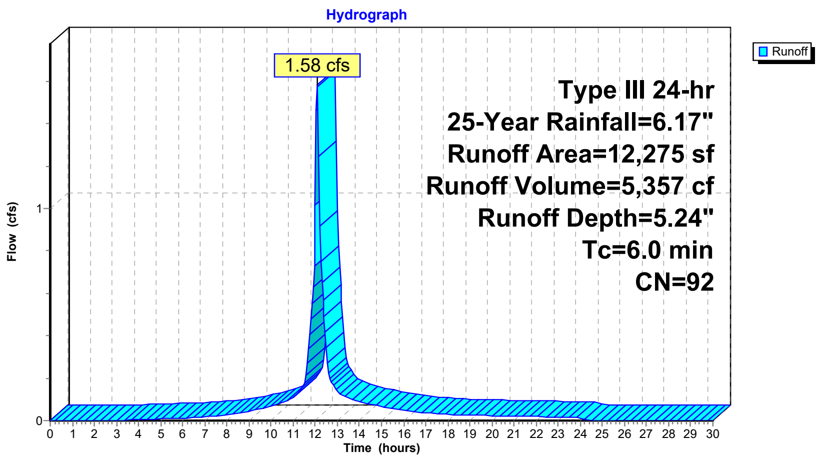
Runoff = 1.58 cfs @ 12.09 hrs, Volume= 5,357 cf, Depth= 5.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
8,053	98	Unconnected pavement, HSG D
4,222	80	>75% Grass cover, Good, HSG D
12,275	92	Weighted Average
4,222		34.40% Pervious Area
8,053		65.60% Impervious Area
8,053		100.00% Unconnected

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

Subcatchment P-16: Entry Driveway



Summary for Subcatchment P-17: Bio-retenion/Rain Garden

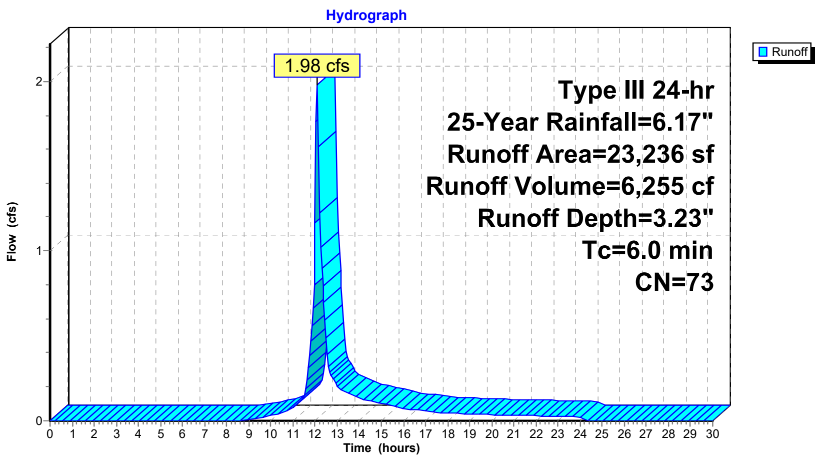
Runoff = 1.98 cfs @ 12.09 hrs, Volume= 6,255 cf, Depth= 3.23"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
23,236	73	Brush, Good, HSG D
0	77	Woods, Good, HSG D
23,236	73	Weighted Average
23,236		100.00% Pervious Area

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

Subcatchment P-17: Bio-retenion/Rain Garden



Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

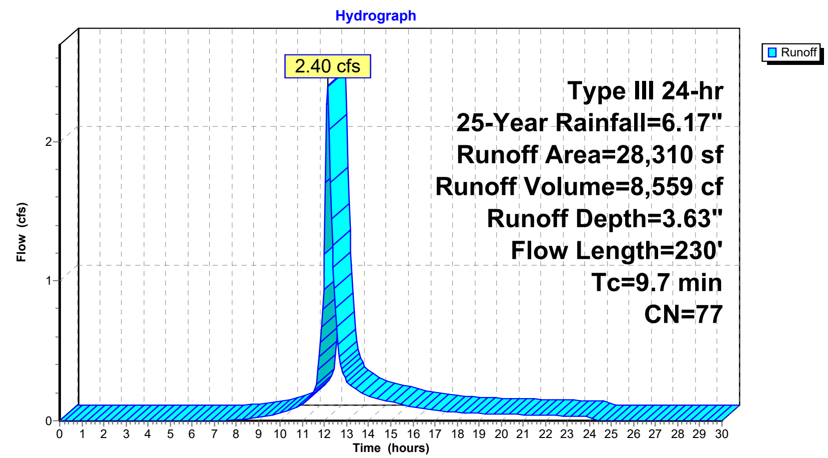
Runoff = 2.40 cfs @ 12.14 hrs, Volume= 8,559 cf, Depth= 3.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
0	80	>75% Grass cover, Good, HSG D
28,310	77	Woods, Good, HSG D
28,310	77	Weighted Average
28,310		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.2980	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.4	180	0.2580	1.27		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	230	Total			

Subcatchment P-2: Direct Flow to Wetlands "F"



Summary for Subcatchment P-3: Flow Southwest Off-Site

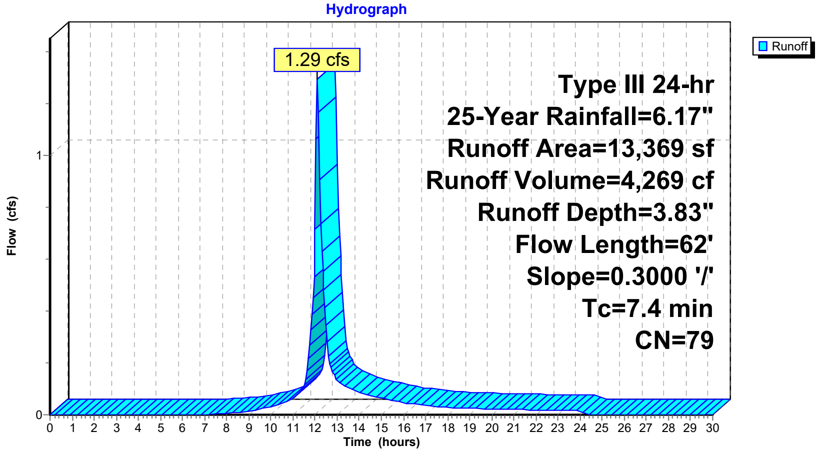
Runoff = 1.29 cfs @ 12.11 hrs, Volume= 4,269 cf, Depth= 3.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
6,978	80	>75% Grass cover, Good, HSG D
5,825	77	Woods, Good, HSG D
566	98	Unconnected pavement, HSG D
13,369	79	Weighted Average
12,803		95.77% Pervious Area
566		4.23% Impervious Area
566		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.3000	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
0.1	12	0.3000	1.37		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
7.4	62	Total			

Subcatchment P-3: Flow Southwest Off-Site



Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

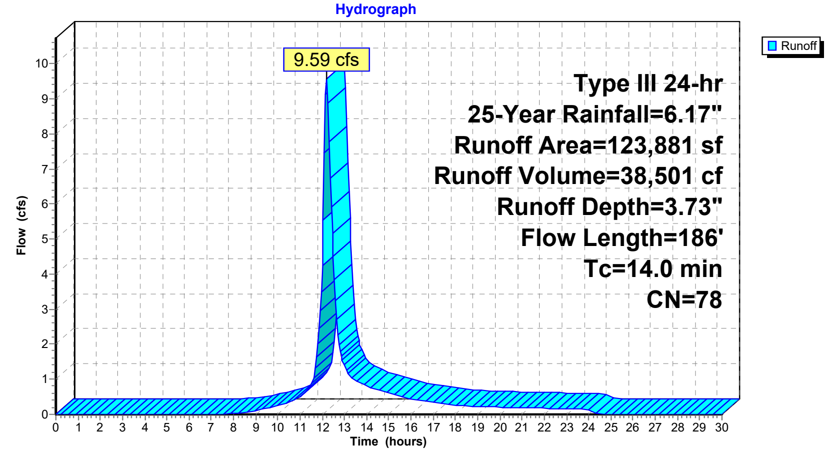
Runoff = 9.59 cfs @ 12.20 hrs, Volume= 38,501 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
90,423	77	Woods, Good, HSG D
32,630	80	>75% Grass cover, Good, HSG D
828	98	Unconnected pavement, HSG D
123,881	78	Weighted Average
123,053		99.33% Pervious Area
828		0.67% Impervious Area
828		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

Subcatchment P-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment P-5: Entrance Drive

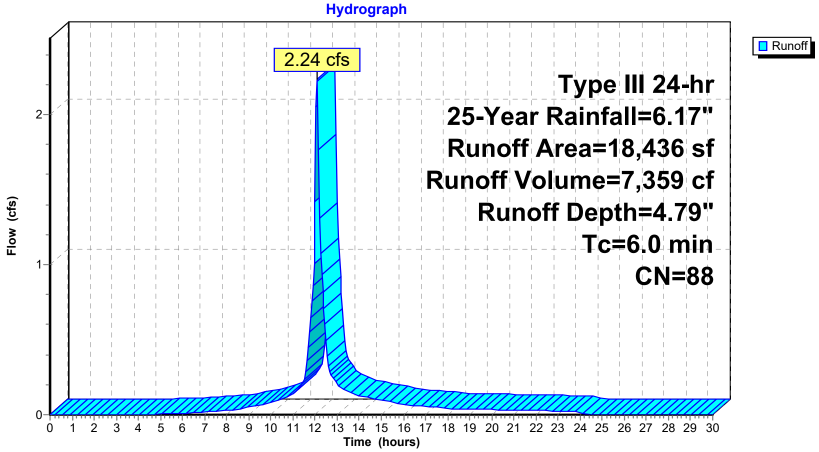
Runoff = 2.24 cfs @ 12.09 hrs, Volume= 7,359 cf, Depth= 4.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
8,637	98	Paved parking, HSG D
9,799	80	>75% Grass cover, Good, HSG D
18,436	88	Weighted Average
9,799		53.15% Pervious Area
8,637		46.85% Impervious Area

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

Subcatchment P-5: Entrance Drive



Summary for Subcatchment P-6: Landcaped Slope/Walls

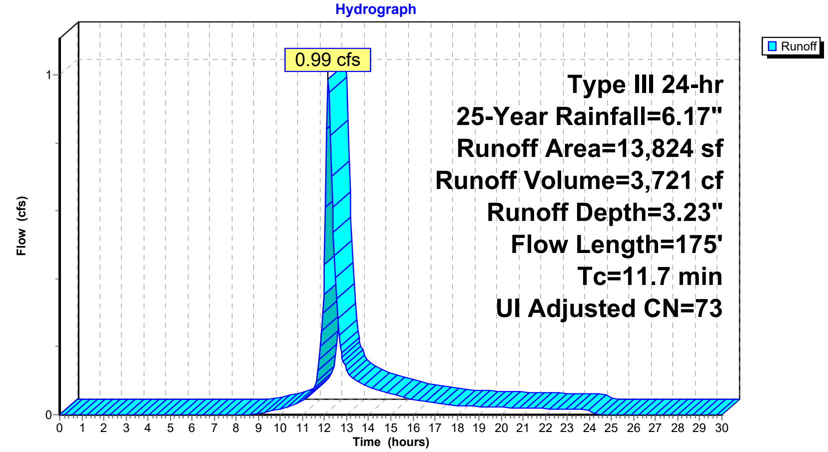
Runoff = 0.99 cfs @ 12.17 hrs, Volume= 3,721 cf, Depth= 3.23"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Adj	Description
13,319	73		Brush, Good, HSG D
505	98		Unconnected pavement, HSG D
13,824	74	73	Weighted Average, UI Adjusted
13,319			96.35% Pervious Area
505			3.65% Impervious Area
505			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.8	50	0.0300	0.08		Sheet Flow, Grass: Bermuda n= 0.410 P2= 3.16"
0.9	125	0.0600	2.40	6.61	Trap/Vee/Rect Channel Flow, Bot.W=4.00' D=0.50' Z= 3.0 '/' Top.W=7.00' n= 0.080 Earth, long dense weeds
11.7	175	Total			

Subcatchment P-6: Landcaped Slope/Walls



Summary for Subcatchment P-7: Landscaped Slope

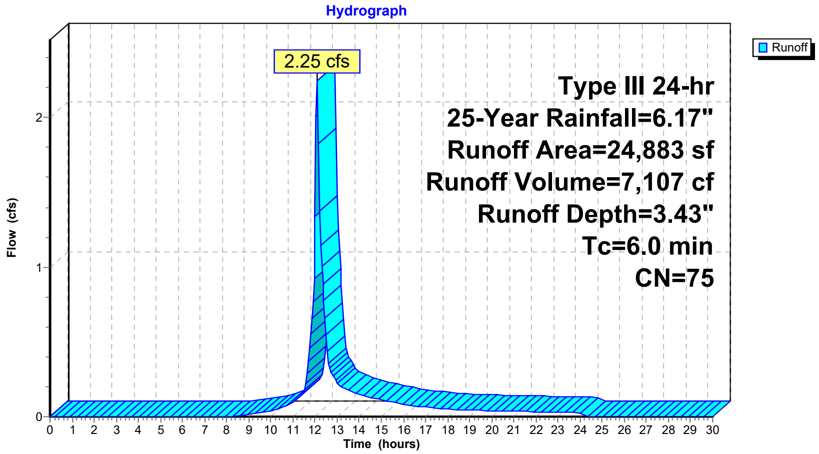
Runoff = 2.25 cfs @ 12.09 hrs, Volume= 7,107 cf, Depth= 3.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
1,622	98	Paved parking, HSG D
23,261	73	Brush, Good, HSG D
24,883	75	Weighted Average
23,261		93.48% Pervious Area
1,622		6.52% Impervious Area

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

Subcatchment P-7: Landscaped Slope



Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

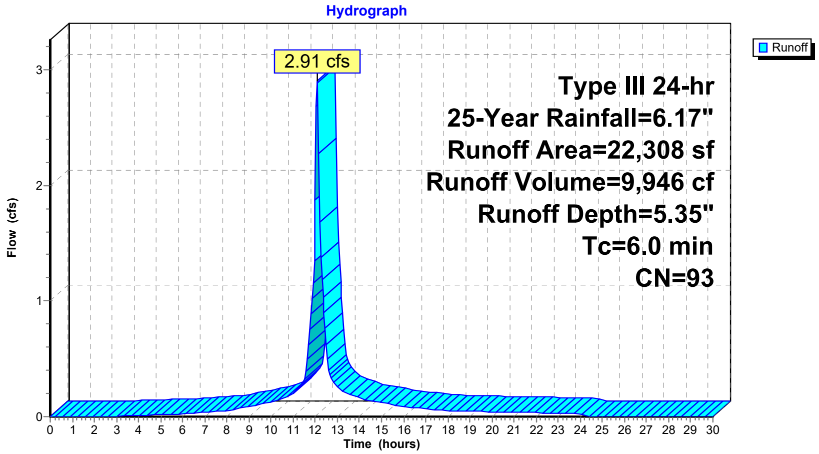
Runoff = 2.91 cfs @ 12.09 hrs, Volume= 9,946 cf, Depth= 5.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
16,606	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,308	93	Weighted Average
5,702		25.56% Pervious Area
16,606		74.44% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

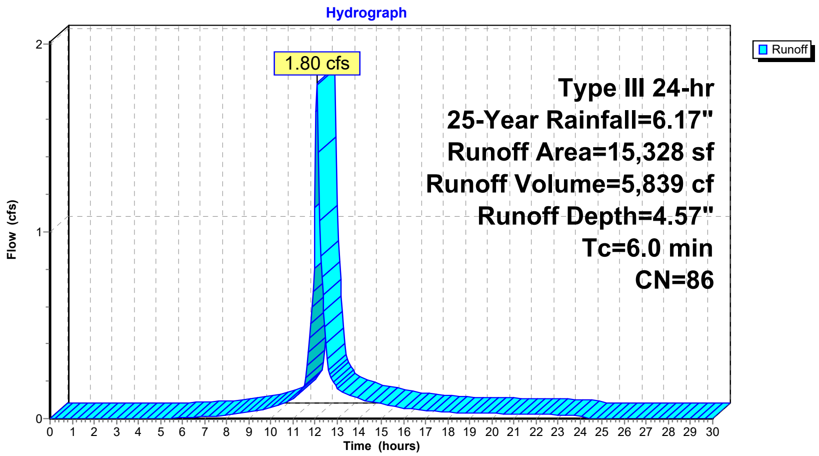
Runoff = 1.80 cfs @ 12.09 hrs, Volume= 5,839 cf, Depth= 4.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



Summary for Reach SWALE: Swale Abutting Entry Driveway

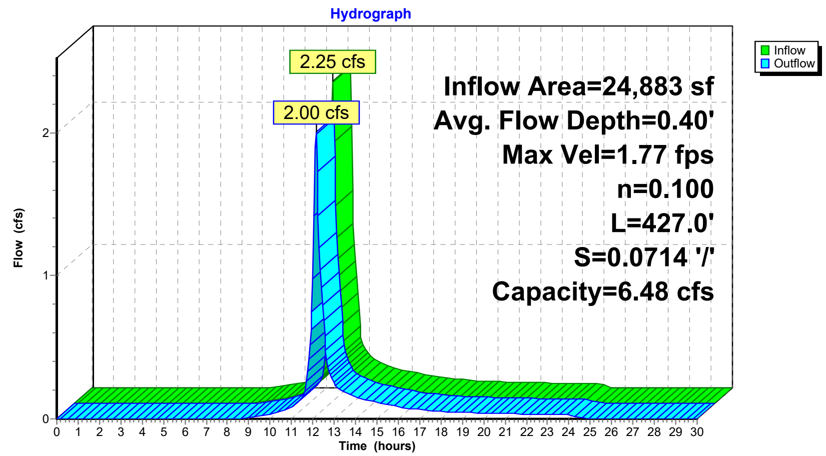
Inflow Area = 24,883 sf, 6.52% Impervious, Inflow Depth = 3.43" for 25-Year event
Inflow = 2.25 cfs @ 12.09 hrs, Volume= 7,107 cf
Outflow = 2.00 cfs @ 12.14 hrs, Volume= 7,107 cf, Atten= 11%, Lag= 2.7 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.77 fps, Min. Travel Time= 4.0 min
Avg. Velocity = 0.48 fps, Avg. Travel Time= 14.8 min

Peak Storage= 483 cf @ 12.14 hrs
Average Depth at Peak Storage= 0.40'
Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 6.48 cfs

2.00' x 0.75' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 2.0 '/' Top Width= 5.00'
Length= 427.0' Slope= 0.0714 '/'
Inlet Invert= 98.00', Outlet Invert= 67.50'

Reach SWALE: Swale Abutting Entry Driveway



Summary for Pond 2P: New Rain Garden/Bioretention Area

Inflow Area = 262,410 sf, 52.33% Impervious, Inflow Depth = 2.38" for 25-Year event
Inflow = 10.71 cfs @ 12.10 hrs, Volume= 52,059 cf
Outflow = 8.79 cfs @ 12.16 hrs, Volume= 51,680 cf, Atten= 18%, Lag= 4.0 min
Discarded = 0.30 cfs @ 12.16 hrs, Volume= 14,627 cf
Primary = 8.49 cfs @ 12.16 hrs, Volume= 37,053 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 59.25' @ 12.16 hrs Surf.Area= 5,289 sf Storage= 6,993 cf

Plug-Flow detention time= 72.5 min calculated for 51,594 cf (99% of inflow)
Center-of-Mass det. time= 69.0 min (938.3 - 869.3)

Volume	Invert	Avail.Storage	Storage Description
#1	57.00'	15,686 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
57.00	1,407	540.0	0	0	1,407
58.00	2,750	481.0	2,041	2,041	6,228
60.00	7,194	732.0	9,595	11,636	30,487
60.50	9,042	748.0	4,050	15,686	32,407

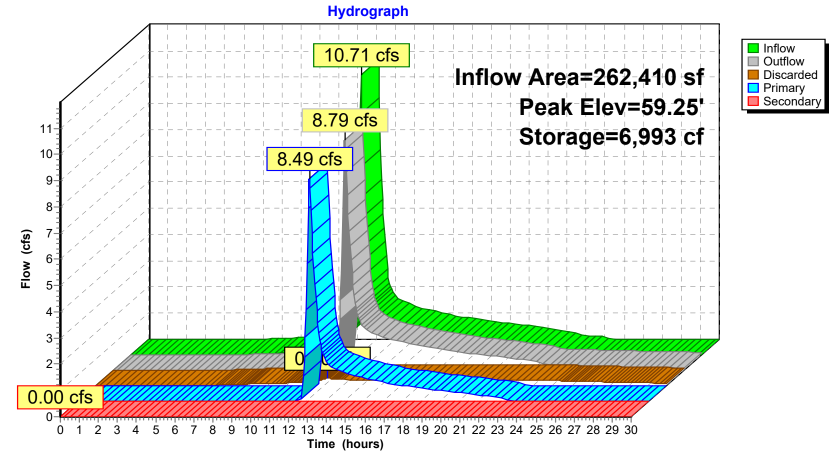
Device	Routing	Invert	Outlet Devices
#1	Primary	57.00'	24.0" Round Culvert L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 57.00' / 56.00' S= 0.0500 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 3.14 sf
#2	Device 1	58.50'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	57.00'	2.410 in/hr Exfiltration over Surface area
#4	Secondary	59.55'	10.0' long x 12.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Discarded OutFlow Max=0.29 cfs @ 12.16 hrs HW=59.25' (Free Discharge)
└3=Exfiltration (Exfiltration Controls 0.29 cfs)

Primary OutFlow Max=8.35 cfs @ 12.16 hrs HW=59.25' (Free Discharge)
└1=Culvert (Passes 8.35 cfs of 13.33 cfs potential flow)
└2=Broad-Crested Rectangular Weir (Weir Controls 8.35 cfs @ 2.80 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=57.00' (Free Discharge)
└4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 2P: New Rain Garden/Bioretention Area



Summary for Pond RG-2: Rain Garden-2 - Entrance

Inflow Area = 32,260 sf, 28.34% Impervious, Inflow Depth = 4.12" for 25-Year event
Inflow = 3.07 cfs @ 12.10 hrs, Volume= 11,080 cf
Outflow = 2.98 cfs @ 12.12 hrs, Volume= 10,721 cf, Atten= 3%, Lag= 0.8 min
Primary = 2.98 cfs @ 12.12 hrs, Volume= 10,721 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 51.38' @ 12.12 hrs Surf.Area= 1,006 sf Storage= 707 cf

Plug-Flow detention time= 42.8 min calculated for 10,703 cf (97% of inflow)
Center-of-Mass det. time= 24.6 min (830.1 - 805.5)

Volume	Invert	Avail.Storage	Storage Description
#1	50.50'	1,444 cf	Rain Garden (Irregular) Listed below (Recalc)

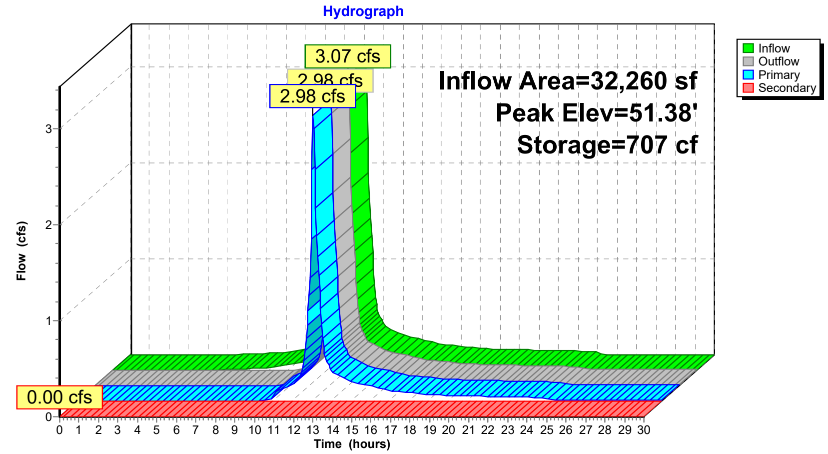
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
50.50	609	143.0	0	0	609
51.50	1,065	161.6	826	826	1,085
52.00	1,414	181.5	618	1,444	1,635

Device	Routing	Invert	Outlet Devices
#1	Primary	47.20'	12.0" Round Culvert L= 120.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.20' / 46.60' S= 0.0050 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	51.15'	2.0" x 2.0" Horiz. Orifice/Grate X 8.00 columns X 8 rows C= 0.600 in 24.0" x 24.0" Grate (44% open area) Limited to weir flow at low heads
#3	Secondary	51.50'	10.0' long x 18.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#4	Device 1	50.50'	0.270 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 47.00' Phase-In= 0.01'

Primary OutFlow Max=2.91 cfs @ 12.12 hrs HW=51.38' (Free Discharge)
└─1=Culvert (Passes 2.91 cfs of 5.15 cfs potential flow)
  ├─2=Orifice/Grate (Weir Controls 2.90 cfs @ 1.57 fps)
  └─4=Exfiltration (Controls 0.01 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=50.50' (Free Discharge)
└─3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond RG-2: Rain Garden-2 - Entrance



Summary for Pond SP-4: Study Point #4

[44] Hint: Outlet device #1 is below defined storage
[79] Warning: Submerged Pond RG-2 Primary device # 1 INLET by 2.39'

Inflow Area = 156,141 sf, 6.39% Impervious, Inflow Depth > 3.78" for 25-Year event
Inflow = 12.11 cfs @ 12.18 hrs, Volume= 49,222 cf
Outflow = 4.87 cfs @ 12.54 hrs, Volume= 49,222 cf, Atten= 60%, Lag= 21.6 min
Primary = 4.87 cfs @ 12.54 hrs, Volume= 49,222 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 49.59' @ 12.54 hrs Surf.Area= 10,111 sf Storage= 9,621 cf

Plug-Flow detention time= 11.7 min calculated for 49,140 cf (100% of inflow)
Center-of-Mass det. time= 11.7 min (838.1 - 826.4)

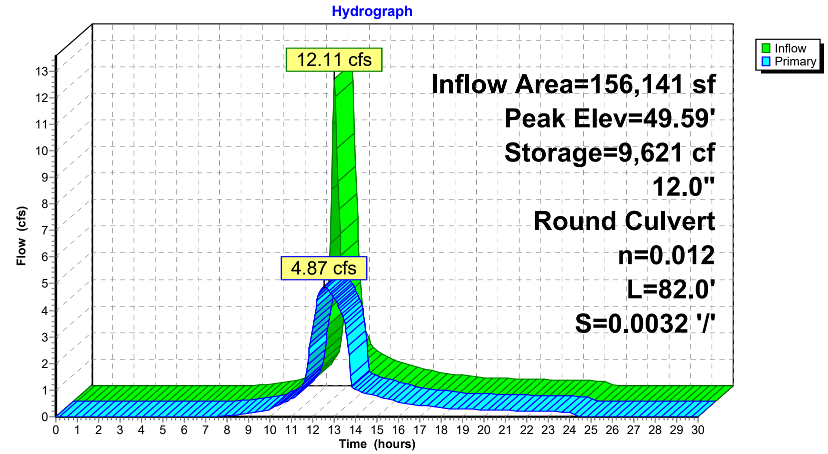
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	12.0" Round Culvert L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=4.87 cfs @ 12.54 hrs HW=49.59' (Free Discharge)
└─1=Culvert (Barrel Controls 4.87 cfs @ 6.20 fps)

Pond SP-4: Study Point #4



Summary for Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

Inflow Area = 158,067 sf, 74.71% Impervious, Inflow Depth = 5.41" for 25-Year event
Inflow = 19.37 cfs @ 12.09 hrs, Volume= 71,246 cf
Outflow = 1.33 cfs @ 13.63 hrs, Volume= 71,246 cf, Atten= 93%, Lag= 92.1 min
Discarded = 0.72 cfs @ 9.60 hrs, Volume= 53,859 cf
Primary = 0.61 cfs @ 13.63 hrs, Volume= 17,388 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 104.78' @ 13.63 hrs Surf.Area= 12,920 sf Storage= 33,426 cf

Plug-Flow detention time= 254.8 min calculated for 71,128 cf (100% of inflow)
Center-of-Mass det. time= 254.8 min (1,018.7 - 763.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	101.00'	22,505 cf	76.00'W x 170.00'L x 9.00'H Field A 116,280 cf Overall - 60,017 cf Embedded = 56,263 cf x 40.0% Voids
#2A	101.50'	60,017 cf	CMP Round 96 x 56 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 56 Chambers in 7 Rows 74.00' Header x 50.27 sf x 1 = 3,719.6 cf Inside
		82,522 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	101.50'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 101.50' / 99.50' S= 0.0200 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Discarded	101.00'	2.410 in/hr Exfiltration over Surface area
#3	Device 1	102.50'	4.0" Vert. Orifice/Grate C= 0.600
#4	Device 1	107.00'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.72 cfs @ 9.60 hrs HW=101.09' (Free Discharge)
└2=Exfiltration (Exfiltration Controls 0.72 cfs)

Primary OutFlow Max=0.61 cfs @ 13.63 hrs HW=104.78' (Free Discharge)
└1=Culvert (Passes 0.61 cfs of 4.98 cfs potential flow)
  ├3=Orifice/Grate (Orifice Controls 0.61 cfs @ 7.00 fps)
  └4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)
Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf
Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

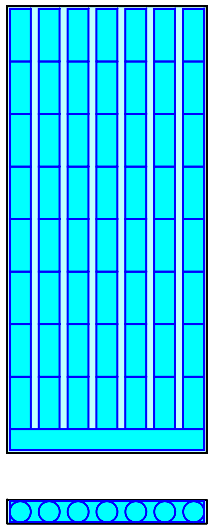
8 Chambers/Row x 20.00' Long +8.00' Header x 1 = 168.00' Row Length +12.0" End Stone x 2 = 170.00' Base Length
7 Rows x 96.0" Wide + 36.0" Spacing x 6 + 12.0" Side Stone x 2 = 76.00' Base Width
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

56 Chambers x 1,005.3 cf + 74.00' Header x 50.27 sf = 60,017.0 cf Chamber Storage

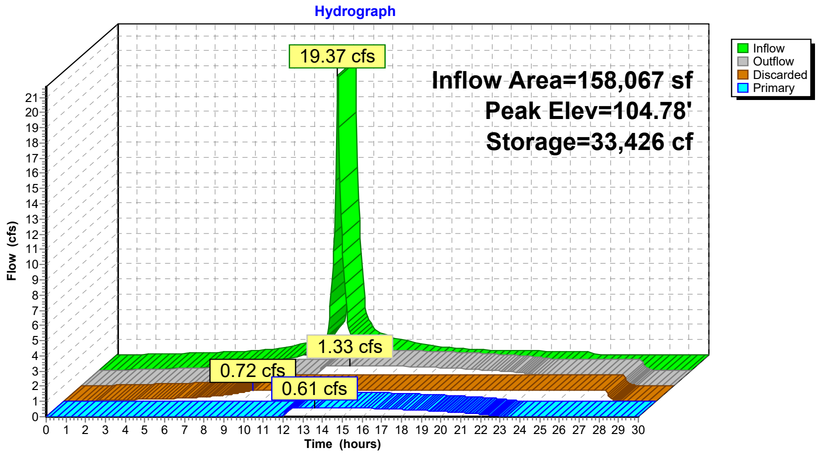
116,280.0 cf Field - 60,017.0 cf Chambers = 56,263.0 cf Stone x 40.0% Voids = 22,505.2 cf Stone Storage

Chamber Storage + Stone Storage = 82,522.2 cf = 1.894 af
Overall Storage Efficiency = 71.0%
Overall System Size = 170.00' x 76.00' x 9.00'

56 Chambers
4,306.7 cy Field
2,083.8 cy Stone



Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

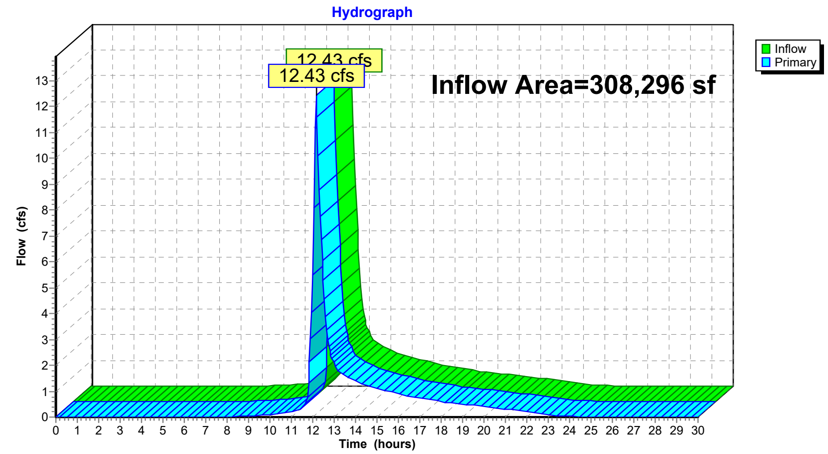


Summary for Link SP-1: Study Point #1

Inflow Area = 308,296 sf, 44.54% Impervious, Inflow Depth = 2.00" for 25-Year event
Inflow = 12.43 cfs @ 12.16 hrs, Volume= 51,314 cf
Primary = 12.43 cfs @ 12.16 hrs, Volume= 51,314 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

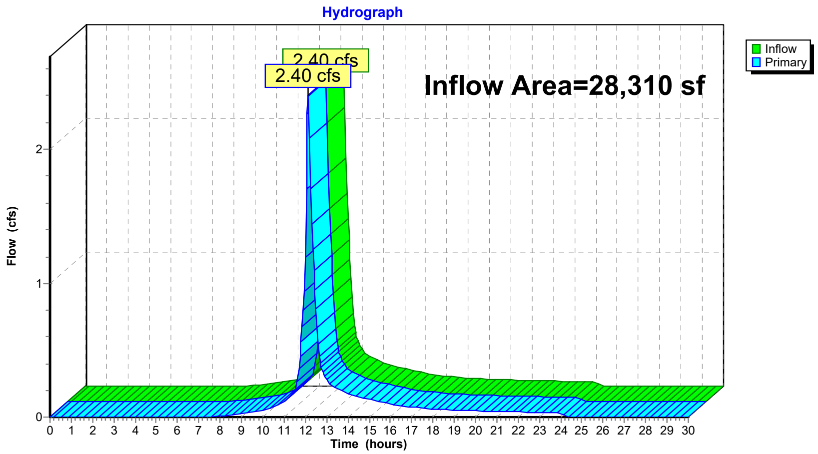


Summary for Link SP-2: Study Point #2

Inflow Area = 28,310 sf, 0.00% Impervious, Inflow Depth = 3.63" for 25-Year event
Inflow = 2.40 cfs @ 12.14 hrs, Volume= 8,559 cf
Primary = 2.40 cfs @ 12.14 hrs, Volume= 8,559 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

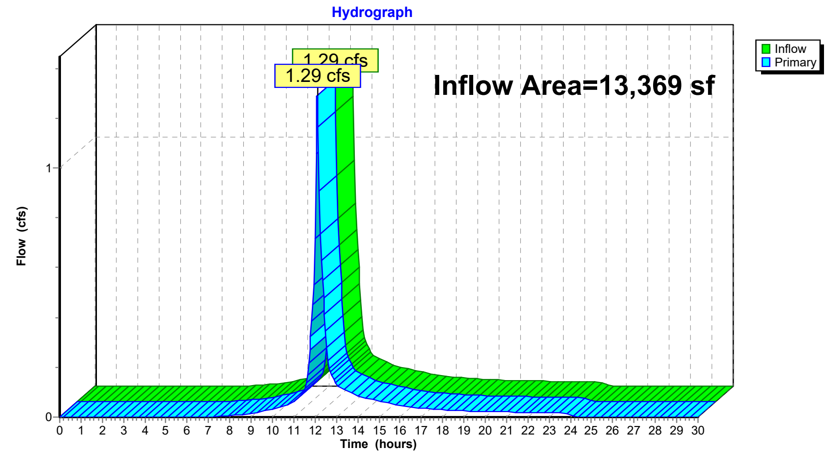


Summary for Link SP-3: Study Point #3

Inflow Area = 13,369 sf, 4.23% Impervious, Inflow Depth = 3.83" for 25-Year event
Inflow = 1.29 cfs @ 12.11 hrs, Volume= 4,269 cf
Primary = 1.29 cfs @ 12.11 hrs, Volume= 4,269 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North — Runoff Area=45,886 sf 0.00% Impervious Runoff Depth=6.13"
Flow Length=148' Tc=9.7 min CN=78 Runoff=6.50 cfs 23,459 cf

Subcatchment P-10: Proposed Building Roof — Runoff Area=30,352 sf 100.00% Impervious Runoff Depth=8.56"
Tc=6.0 min CN=98 Runoff=5.88 cfs 21,650 cf

Subcatchment P-11: South Courtyard — Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=8.56"
Tc=6.0 min CN=98 Runoff=3.91 cfs 14,395 cf

Subcatchment P-12: Southeast Roof Area — Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=8.56"
Tc=6.0 min CN=98 Runoff=5.28 cfs 19,441 cf

Subcatchment P-13: Main Parking Area — Runoff Area=18,475 sf 73.00% Impervious Runoff Depth=7.96"
Tc=6.0 min CN=93 Runoff=3.50 cfs 12,251 cf

Subcatchment P-14: Southwest Lawn — Runoff Area=24,170 sf 21.35% Impervious Runoff Depth=6.87"
Flow Length=245' Tc=13.3 min CN=84 Runoff=3.39 cfs 13,829 cf

Subcatchment P-15: Lawn/Fire Access — Runoff Area=43,949 sf 21.71% Impervious Runoff Depth=6.87"
Tc=6.0 min CN=84 Runoff=7.64 cfs 25,145 cf

Subcatchment P-16: Entry Driveway — Runoff Area=12,275 sf 65.60% Impervious Runoff Depth=7.84"
Tc=6.0 min CN=92 Runoff=2.31 cfs 8,016 cf

Subcatchment P-17: Bio-retenion/Rain Garden — Runoff Area=23,236 sf 0.00% Impervious Runoff Depth=5.53"
Tc=6.0 min CN=73 Runoff=3.37 cfs 10,698 cf

Subcatchment P-2: Direct Flow to Wetlands "F" — Runoff Area=28,310 sf 0.00% Impervious Runoff Depth=6.01"
Flow Length=230' Tc=9.7 min CN=77 Runoff=3.94 cfs 14,186 cf

Subcatchment P-3: Flow Southwest Off-Site — Runoff Area=13,369 sf 4.23% Impervious Runoff Depth=6.26"
Flow Length=62' Slope=0.3000 '/' Tc=7.4 min CN=79 Runoff=2.08 cfs 6,971 cf

Subcatchment P-4: Flow Southeast to Wetlands "A" — Runoff Area=123,881 sf 0.67% Impervious Runoff Depth=6.13"
Flow Length=186' Tc=14.0 min CN=78 Runoff=15.60 cfs 63,333 cf

Subcatchment P-5: Entrance Drive — Runoff Area=18,436 sf 46.85% Impervious Runoff Depth=7.35"
Tc=6.0 min CN=88 Runoff=3.36 cfs 11,295 cf

Subcatchment P-6: Landcaped Slope/Walls — Runoff Area=13,824 sf 3.65% Impervious Runoff Depth=5.53"
Flow Length=175' Tc=11.7 min UI Adjusted CN=73 Runoff=1.69 cfs 6,365 cf

Subcatchment P-7: Landscaped Slope — Runoff Area=24,883 sf 6.52% Impervious Runoff Depth=5.77"
Tc=6.0 min CN=75 Runoff=3.75 cfs 11,962 cf

Subcatchment P-8: Cul-de-Sac/Garage Turn Around — Runoff Area=22,308 sf 74.44% Impervious Runoff Depth=7.96"
Tc=6.0 min CN=93 Runoff=4.23 cfs 14,792 cf

Subcatchment P-9: North Courtyard/Green Roof — Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=7.11"
Tc=6.0 min CN=86 Runoff=2.73 cfs 9,080 cf

Reach SWALE: Swale Abutting Entry Driveway — Avg. Flow Depth=0.54' Max Vel=2.06 fps Inflow=3.75 cfs 11,962 cf
n=0.100 L=427.0' S=0.0714 '/' Capacity=6.48 cfs Outflow=3.40 cfs 11,962 cf

Pond 2P: New Rain Garden/Bioretention Area — Peak Elev=59.53' Storage=8,565 cf Inflow=17.11 cfs 91,820 cf
Discarded=0.33 cfs 17,304 cf Primary=13.94 cfs 72,447 cf Secondary=0.00 cfs 0 cf Outflow=14.27 cfs 89,750 cf

Pond RG-2: Rain Garden-2 - Entrance — Peak Elev=51.47' Storage=791 cf Inflow=4.79 cfs 17,659 cf
Primary=4.67 cfs 17,300 cf Secondary=0.00 cfs 0 cf Outflow=4.67 cfs 17,300 cf

Pond SP-4: Study Point #4 — Peak Elev=50.49' Storage=20,805 cf Inflow=19.67 cfs 80,633 cf
12.0" Round Culvert n=0.012 L=82.0' S=0.0032 '/' Outflow=5.78 cfs 80,633 cf

Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP) — Peak Elev=106.78' Storage=55,050 cf Inflow=28.21 cfs 105,437 cf
Discarded=0.72 cfs 63,670 cf Primary=0.85 cfs 35,998 cf Outflow=1.57 cfs 99,668 cf

Link SP-1: Study Point #1 — Inflow=20.37 cfs 95,906 cf
Primary=20.37 cfs 95,906 cf

Link SP-2: Study Point #2 — Inflow=3.94 cfs 14,186 cf
Primary=3.94 cfs 14,186 cf

Link SP-3: Study Point #3 — Inflow=2.08 cfs 6,971 cf
Primary=2.08 cfs 6,971 cf

Total Runoff Area = 506,116 sf Runoff Volume = 286,867 cf Average Runoff Depth = 6.80"
70.79% Pervious = 358,265 sf 29.21% Impervious = 147,851 sf

Summary for Subcatchment P-1: Flow to Wetlands - North

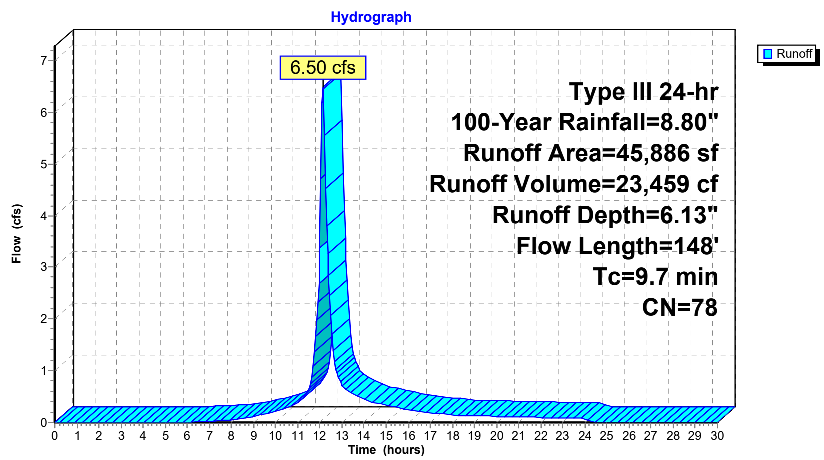
Runoff = 6.50 cfs @ 12.14 hrs, Volume= 23,459 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
9,993	80	>75% Grass cover, Good, HSG D
35,893	77	Woods, Good, HSG D
45,886	78	Weighted Average
45,886		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	50	0.2120	0.10		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
1.3	98	0.2620	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	148	Total			

Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

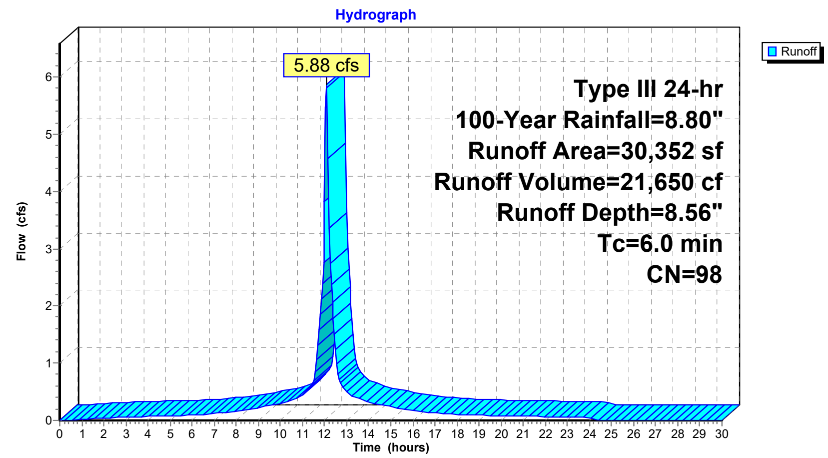
Runoff = 5.88 cfs @ 12.09 hrs, Volume= 21,650 cf, Depth= 8.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
30,352	98	Unconnected roofs, HSG D
30,352		100.00% Impervious Area
30,352		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

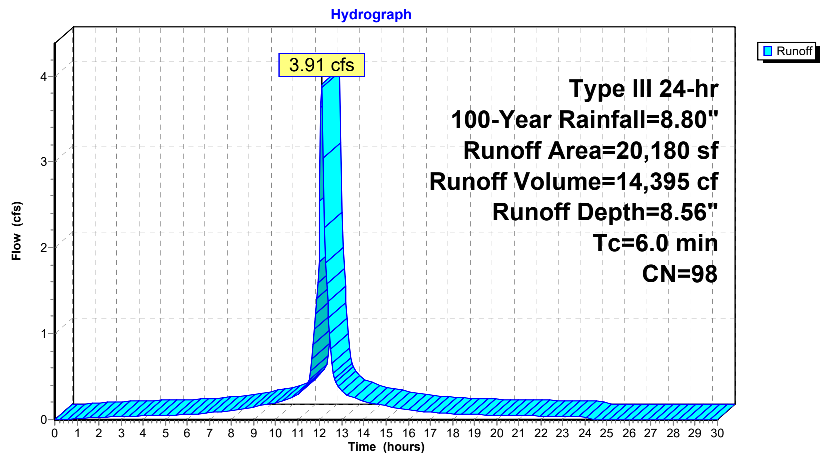
Runoff = 3.91 cfs @ 12.09 hrs, Volume= 14,395 cf, Depth= 8.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

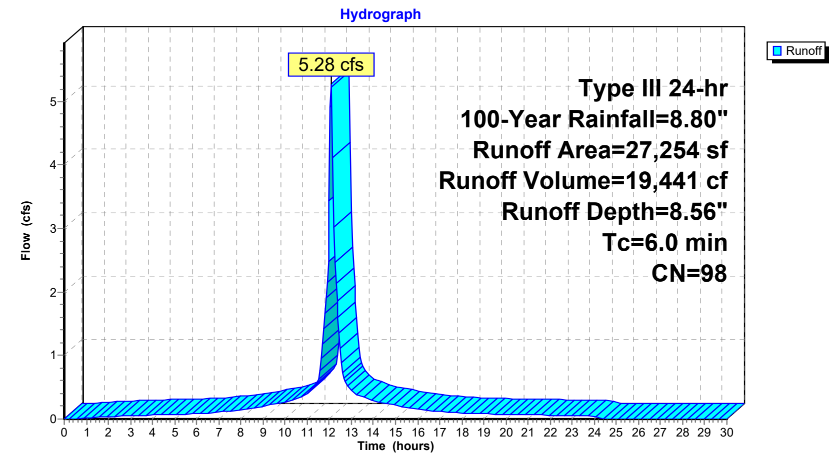
Runoff = 5.28 cfs @ 12.09 hrs, Volume= 19,441 cf, Depth= 8.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

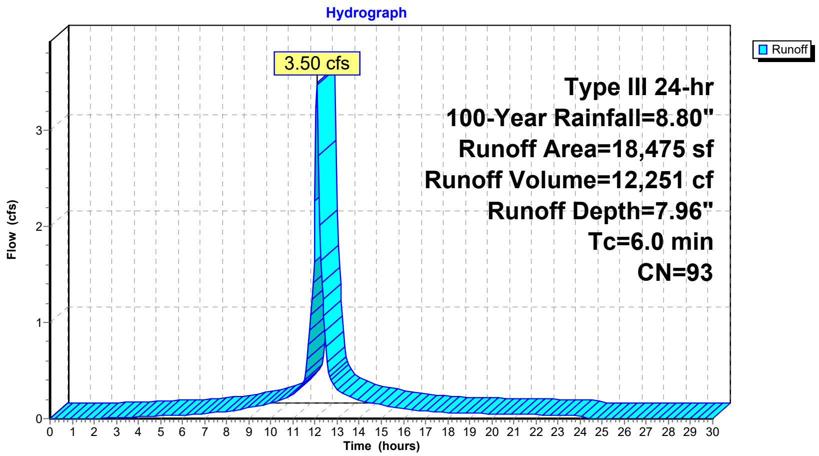
Runoff = 3.50 cfs @ 12.09 hrs, Volume= 12,251 cf, Depth= 7.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
13,486	98	Unconnected pavement, HSG D
4,989	80	>75% Grass cover, Good, HSG D
18,475	93	Weighted Average
4,989		27.00% Pervious Area
13,486		73.00% Impervious Area
13,486		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: Southwest Lawn

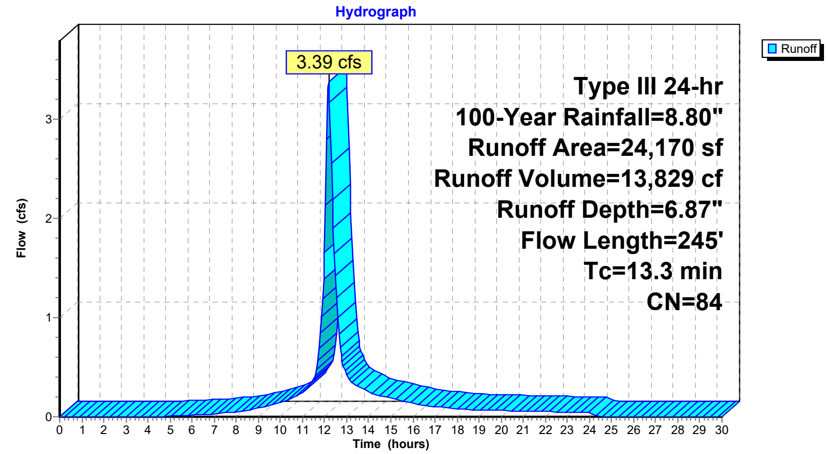
Runoff = 3.39 cfs @ 12.18 hrs, Volume= 13,829 cf, Depth= 6.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
5,161	98	Paved parking, HSG D
19,009	80	>75% Grass cover, Good, HSG D
24,170	84	Weighted Average
19,009		78.65% Pervious Area
5,161		21.35% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	50	0.0100	0.08		Sheet Flow, Grass: Dense n= 0.240 P2= 3.16"
1.9	80	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.5	115	0.0400	4.06		Shallow Concentrated Flow, Paved Kv= 20.3 fps
13.3	245	Total			

Subcatchment P-14: Southwest Lawn



Summary for Subcatchment P-15: Lawn/Fire Access

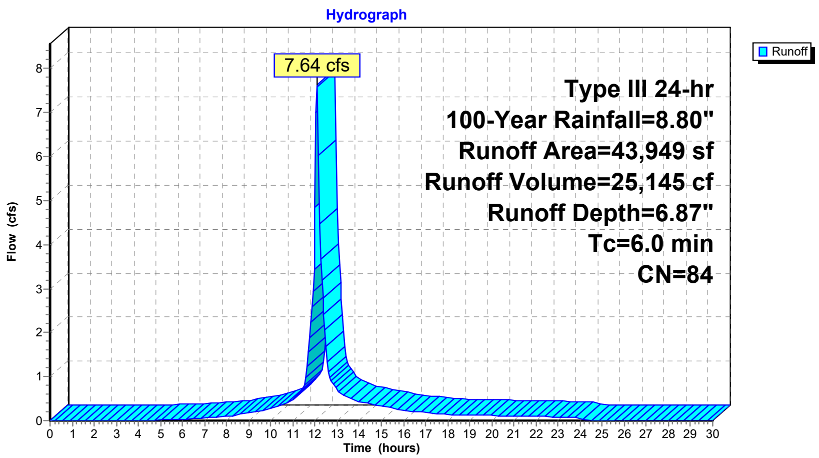
Runoff = 7.64 cfs @ 12.09 hrs, Volume= 25,145 cf, Depth= 6.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

	Area (sf)	CN	Description
	9,543	98	Paved parking, HSG D
*	3,854	80	GrassPave2, Good, HSG D
	30,552	80	>75% Grass cover, Good, HSG D
	43,949	84	Weighted Average
	34,406		78.29% Pervious Area
	9,543		21.71% Impervious Area

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

Subcatchment P-15: Lawn/Fire Access



Summary for Subcatchment P-16: Entry Driveway

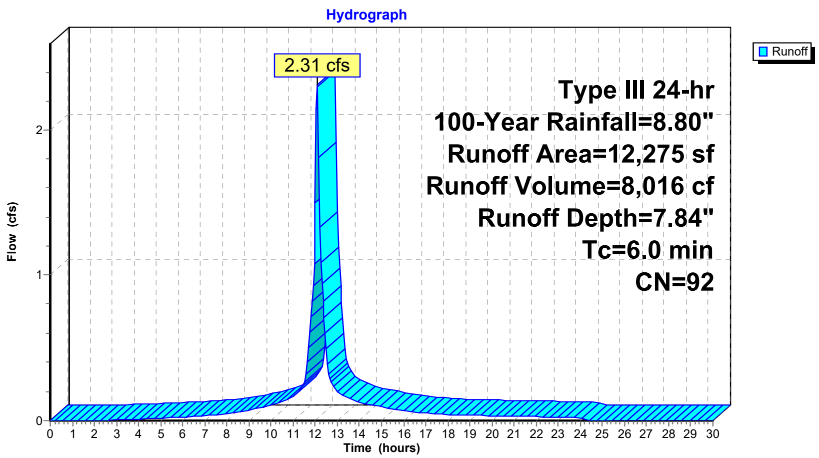
Runoff = 2.31 cfs @ 12.09 hrs, Volume= 8,016 cf, Depth= 7.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
8,053	98	Unconnected pavement, HSG D
4,222	80	>75% Grass cover, Good, HSG D
12,275	92	Weighted Average
4,222		34.40% Pervious Area
8,053		65.60% Impervious Area
8,053		100.00% Unconnected

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

Subcatchment P-16: Entry Driveway



Summary for Subcatchment P-17: Bio-retenion/Rain Garden

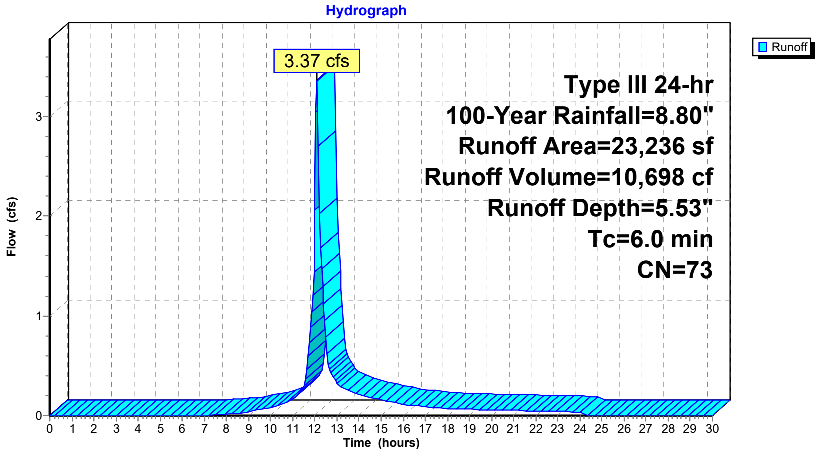
Runoff = 3.37 cfs @ 12.09 hrs, Volume= 10,698 cf, Depth= 5.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
23,236	73	Brush, Good, HSG D
0	77	Woods, Good, HSG D
23,236	73	Weighted Average
23,236		100.00% Pervious Area

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

Subcatchment P-17: Bio-retenion/Rain Garden



Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

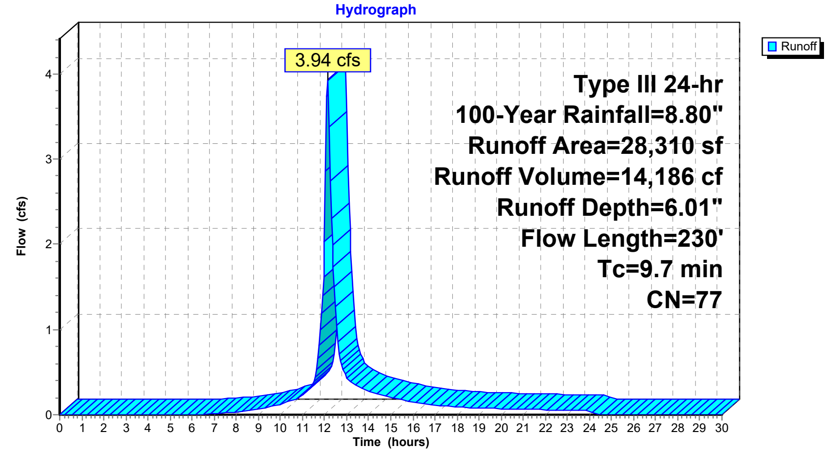
Runoff = 3.94 cfs @ 12.14 hrs, Volume= 14,186 cf, Depth= 6.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
0	80	>75% Grass cover, Good, HSG D
28,310	77	Woods, Good, HSG D
28,310	77	Weighted Average
28,310		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.2980	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.4	180	0.2580	1.27		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.7	230	Total			

Subcatchment P-2: Direct Flow to Wetlands "F"



Summary for Subcatchment P-3: Flow Southwest Off-Site

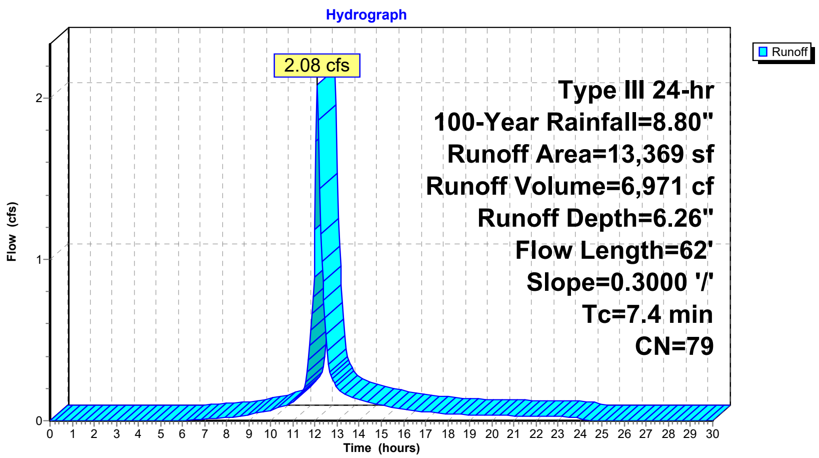
Runoff = 2.08 cfs @ 12.11 hrs, Volume= 6,971 cf, Depth= 6.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
6,978	80	>75% Grass cover, Good, HSG D
5,825	77	Woods, Good, HSG D
566	98	Unconnected pavement, HSG D
13,369	79	Weighted Average
12,803		95.77% Pervious Area
566		4.23% Impervious Area
566		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.3000	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
0.1	12	0.3000	1.37		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
7.4	62	Total			

Subcatchment P-3: Flow Southwest Off-Site



Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 mimutes for E-2.

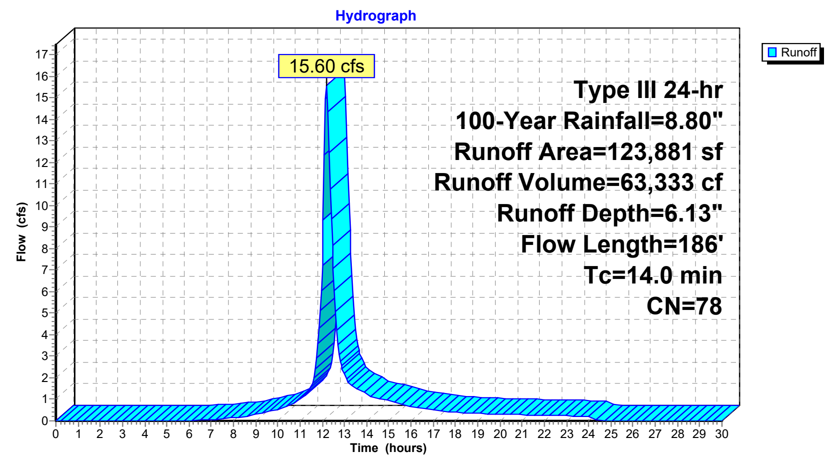
Runoff = 15.60 cfs @ 12.19 hrs, Volume= 63,333 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
90,423	77	Woods, Good, HSG D
32,630	80	>75% Grass cover, Good, HSG D
828	98	Unconnected pavement, HSG D
123,881	78	Weighted Average
123,053		99.33% Pervious Area
828		0.67% Impervious Area
828		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

Subcatchment P-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment P-5: Entrance Drive

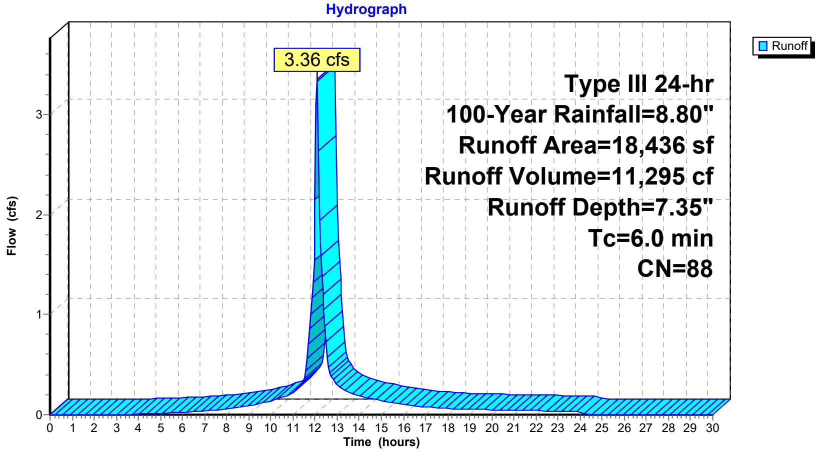
Runoff = 3.36 cfs @ 12.09 hrs, Volume= 11,295 cf, Depth= 7.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
8,637	98	Paved parking, HSG D
9,799	80	>75% Grass cover, Good, HSG D
18,436	88	Weighted Average
9,799		53.15% Pervious Area
8,637		46.85% Impervious Area

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

Subcatchment P-5: Entrance Drive



Summary for Subcatchment P-6: Landcaped Slope/Walls

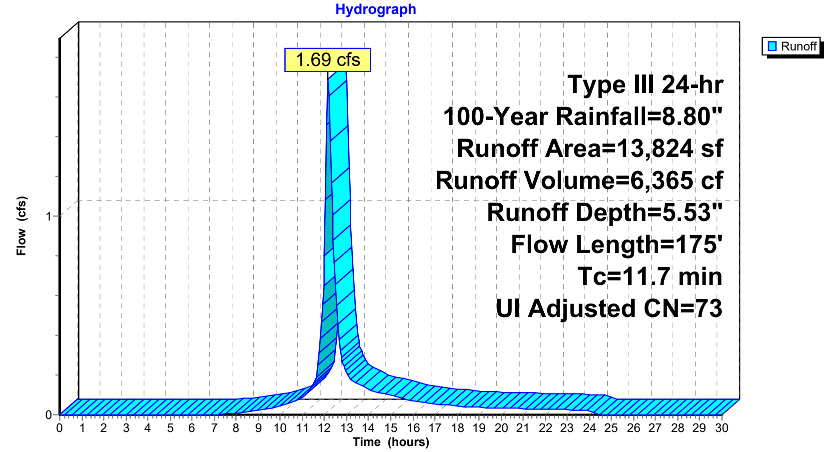
Runoff = 1.69 cfs @ 12.16 hrs, Volume= 6,365 cf, Depth= 5.53"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Adj	Description
13,319	73		Brush, Good, HSG D
505	98		Unconnected pavement, HSG D
13,824	74	73	Weighted Average, UI Adjusted
13,319			96.35% Pervious Area
505			3.65% Impervious Area
505			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.8	50	0.0300	0.08		Sheet Flow, Grass: Bermuda n= 0.410 P2= 3.16"
0.9	125	0.0600	2.40	6.61	Trap/Vee/Rect Channel Flow, Bot.W=4.00' D=0.50' Z= 3.0 '/' Top.W=7.00' n= 0.080 Earth, long dense weeds
11.7	175	Total			

Subcatchment P-6: Landcaped Slope/Walls



Summary for Subcatchment P-7: Landscaped Slope

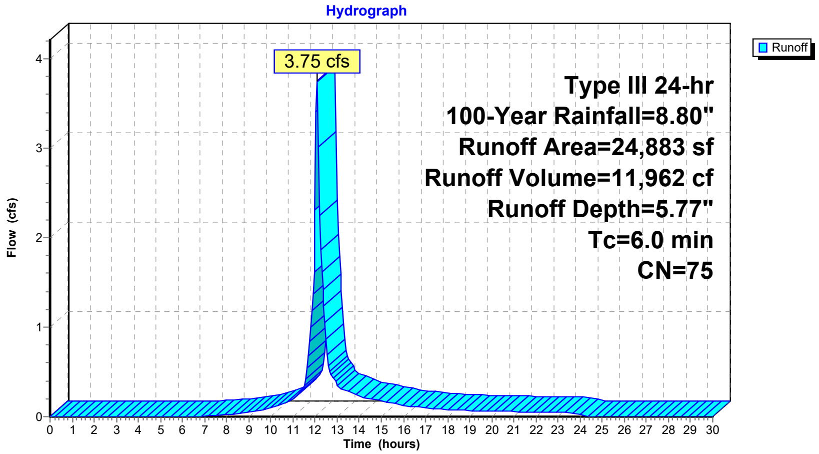
Runoff = 3.75 cfs @ 12.09 hrs, Volume= 11,962 cf, Depth= 5.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
1,622	98	Paved parking, HSG D
23,261	73	Brush, Good, HSG D
24,883	75	Weighted Average
23,261		93.48% Pervious Area
1,622		6.52% Impervious Area

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

Subcatchment P-7: Landscaped Slope



Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

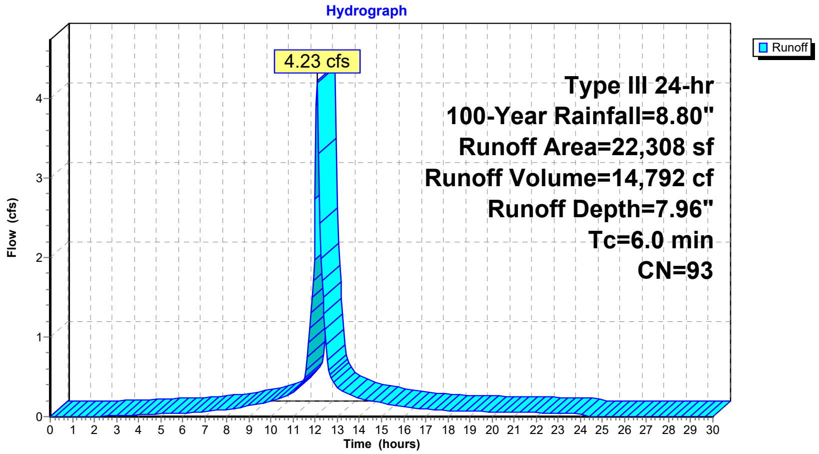
Runoff = 4.23 cfs @ 12.09 hrs, Volume= 14,792 cf, Depth= 7.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
16,606	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,308	93	Weighted Average
5,702		25.56% Pervious Area
16,606		74.44% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

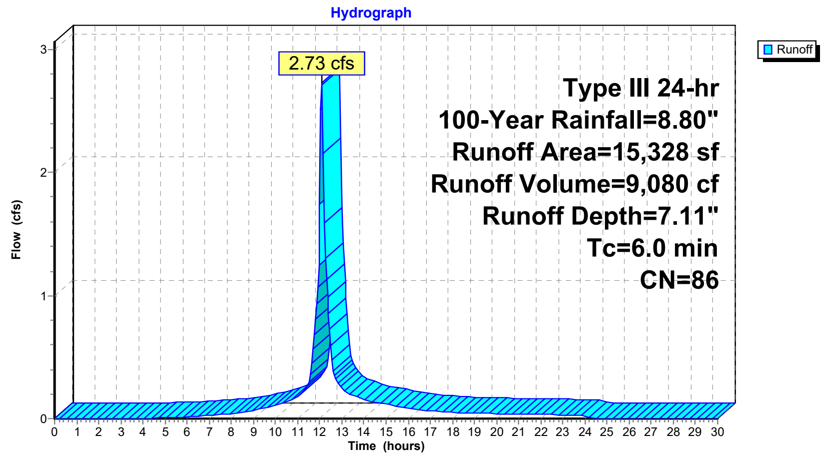
Runoff = 2.73 cfs @ 12.09 hrs, Volume= 9,080 cf, Depth= 7.11"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



Summary for Reach SWALE: Swale Abutting Entry Driveway

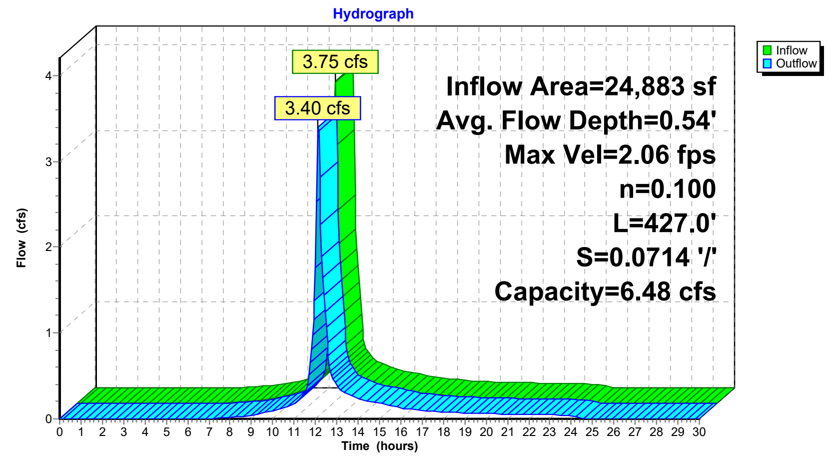
Inflow Area = 24,883 sf, 6.52% Impervious, Inflow Depth = 5.77" for 100-Year event
Inflow = 3.75 cfs @ 12.09 hrs, Volume= 11,962 cf
Outflow = 3.40 cfs @ 12.13 hrs, Volume= 11,962 cf, Atten= 9%, Lag= 2.3 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.06 fps, Min. Travel Time= 3.5 min
Avg. Velocity = 0.55 fps, Avg. Travel Time= 12.8 min

Peak Storage= 704 cf @ 12.13 hrs
Average Depth at Peak Storage= 0.54'
Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 6.48 cfs

2.00' x 0.75' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 2.0 '/' Top Width= 5.00'
Length= 427.0' Slope= 0.0714 '/'
Inlet Invert= 98.00', Outlet Invert= 67.50'

Reach SWALE: Swale Abutting Entry Driveway



Summary for Pond 2P: New Rain Garden/Bioretention Area

Inflow Area = 262,410 sf, 52.33% Impervious, Inflow Depth = 4.20" for 100-Year event
Inflow = 17.11 cfs @ 12.10 hrs, Volume= 91,820 cf
Outflow = 14.27 cfs @ 12.16 hrs, Volume= 89,750 cf, Atten= 17%, Lag= 3.7 min
Discarded = 0.33 cfs @ 12.16 hrs, Volume= 17,304 cf
Primary = 13.94 cfs @ 12.16 hrs, Volume= 72,447 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 59.53' @ 12.16 hrs Surf.Area= 5,968 sf Storage= 8,565 cf

Plug-Flow detention time= 51.2 min calculated for 89,601 cf (98% of inflow)
Center-of-Mass det. time= 36.3 min (955.3 - 919.0)

Volume	Invert	Avail.Storage	Storage Description
#1	57.00'	15,686 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
57.00	1,407	540.0	0	0	1,407
58.00	2,750	481.0	2,041	2,041	6,228
60.00	7,194	732.0	9,595	11,636	30,487
60.50	9,042	748.0	4,050	15,686	32,407

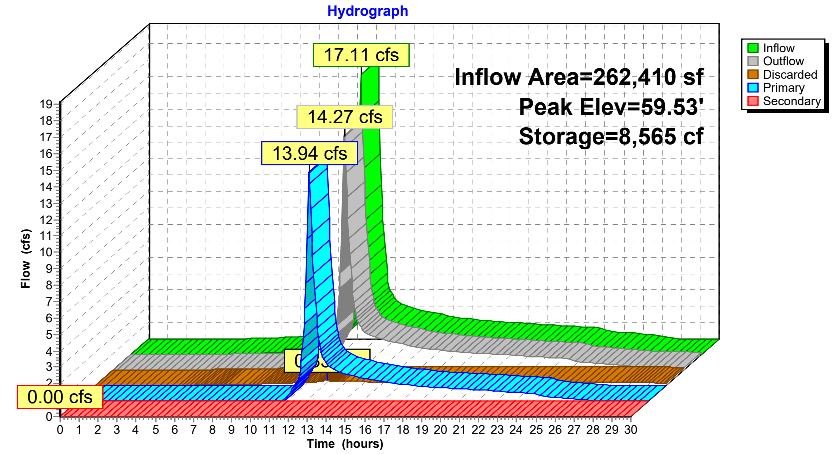
Device	Routing	Invert	Outlet Devices
#1	Primary	57.00'	24.0" Round Culvert L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 57.00' / 56.00' S= 0.0500 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 3.14 sf
#2	Device 1	58.50'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	57.00'	2.410 in/hr Exfiltration over Surface area
#4	Secondary	59.55'	10.0' long x 12.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64

Discarded OutFlow Max=0.33 cfs @ 12.16 hrs HW=59.53' (Free Discharge)
└3=Exfiltration (Exfiltration Controls 0.33 cfs)

Primary OutFlow Max=13.82 cfs @ 12.16 hrs HW=59.53' (Free Discharge)
└1=Culvert (Passes 13.82 cfs of 14.76 cfs potential flow)
  └2=Broad-Crested Rectangular Weir (Weir Controls 13.82 cfs @ 3.36 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=57.00' (Free Discharge)
└4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond 2P: New Rain Garden/Bioretention Area



Summary for Pond RG-2: Rain Garden-2 - Entrance

Inflow Area = 32,260 sf, 28.34% Impervious, Inflow Depth = 6.57" for 100-Year event
Inflow = 4.79 cfs @ 12.10 hrs, Volume= 17,659 cf
Outflow = 4.67 cfs @ 12.12 hrs, Volume= 17,300 cf, Atten= 3%, Lag= 0.7 min
Primary = 4.67 cfs @ 12.12 hrs, Volume= 17,300 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 3
Peak Elev= 51.47' @ 12.12 hrs Surf.Area= 1,048 sf Storage= 791 cf

Plug-Flow detention time= 29.9 min calculated for 17,271 cf (98% of inflow)
Center-of-Mass det. time= 18.1 min (811.9 - 793.8)

Volume	Invert	Avail.Storage	Storage Description
#1	50.50'	1,444 cf	Rain Garden (Irregular) Listed below (Recalc)

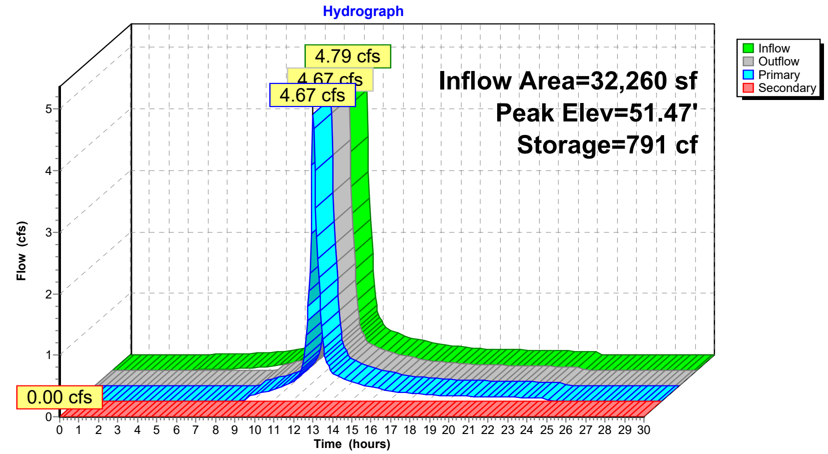
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
50.50	609	143.0	0	0	609
51.50	1,065	161.6	826	826	1,085
52.00	1,414	181.5	618	1,444	1,635

Device	Routing	Invert	Outlet Devices
#1	Primary	47.20'	12.0" Round Culvert L= 120.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.20' / 46.60' S= 0.0050 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	51.15'	2.0" x 2.0" Horiz. Orifice/Grate X 8.00 columns X 8 rows C= 0.600 in 24.0" x 24.0" Grate (44% open area) Limited to weir flow at low heads
#3	Secondary	51.50'	10.0' long x 18.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63
#4	Device 1	50.50'	0.270 in/hr Exfiltration over Surface area Conductivity to Groundwater Elevation = 47.00' Phase-In= 0.01'

Primary OutFlow Max=4.56 cfs @ 12.12 hrs HW=51.46' (Free Discharge)
1=Culvert (Passes 4.56 cfs of 5.20 cfs potential flow)
2=Orifice/Grate (Weir Controls 4.56 cfs @ 1.83 fps)
4=Exfiltration (Controls 0.01 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=50.50' (Free Discharge)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Pond RG-2: Rain Garden-2 - Entrance



Summary for Pond SP-4: Study Point #4

[44] Hint: Outlet device #1 is below defined storage
[79] Warning: Submerged Pond RG-2 Primary device # 1 INLET by 3.29'

Inflow Area = 156,141 sf, 6.39% Impervious, Inflow Depth > 6.20" for 100-Year event
Inflow = 19.67 cfs @ 12.17 hrs, Volume= 80,633 cf
Outflow = 5.78 cfs @ 12.61 hrs, Volume= 80,633 cf, Atten= 71%, Lag= 26.5 min
Primary = 5.78 cfs @ 12.61 hrs, Volume= 80,633 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 50.49' @ 12.61 hrs Surf.Area= 15,747 sf Storage= 20,805 cf

Plug-Flow detention time= 23.5 min calculated for 80,633 cf (100% of inflow)
Center-of-Mass det. time= 23.5 min (834.9 - 811.4)

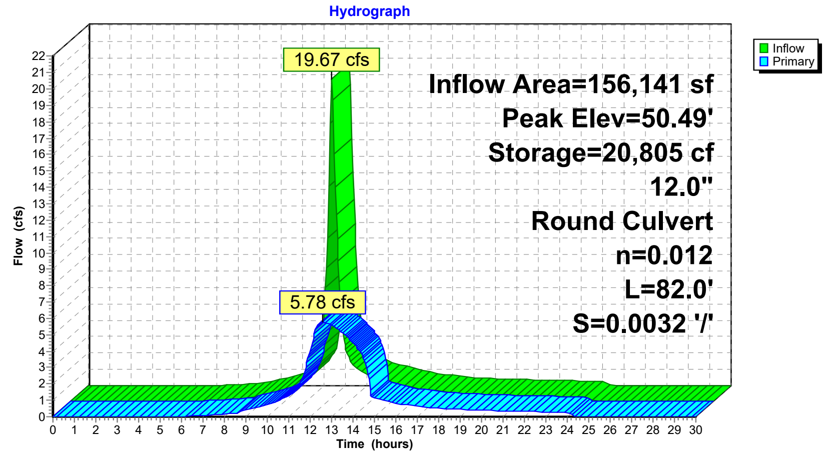
Volume	Invert	Avail.Storage	Storage Description
#1	47.00'	30,097 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
47.00	74	35.0	0	0	74
48.00	970	145.0	437	437	1,652
49.00	7,933	434.0	3,892	4,330	14,971
50.00	11,795	605.0	9,800	14,130	29,119
51.00	20,540	853.0	15,967	30,097	57,902

Device	Routing	Invert	Outlet Devices
#1	Primary	46.64'	12.0" Round Culvert L= 82.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 46.64' / 46.38' S= 0.0032 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.79 sf

Primary OutFlow Max=5.78 cfs @ 12.61 hrs HW=50.49' (Free Discharge)
└1=Culvert (Barrel Controls 5.78 cfs @ 7.36 fps)

Pond SP-4: Study Point #4



Summary for Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

Inflow Area = 158,067 sf, 74.71% Impervious, Inflow Depth = 8.00" for 100-Year event
Inflow = 28.21 cfs @ 12.09 hrs, Volume= 105,437 cf
Outflow = 1.57 cfs @ 14.10 hrs, Volume= 99,668 cf, Atten= 94%, Lag= 120.5 min
Discarded = 0.72 cfs @ 8.45 hrs, Volume= 63,670 cf
Primary = 0.85 cfs @ 14.10 hrs, Volume= 35,998 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Peak Elev= 106.78' @ 14.10 hrs Surf.Area= 12,920 sf Storage= 55,050 cf

Plug-Flow detention time= 350.0 min calculated for 99,502 cf (94% of inflow)
Center-of-Mass det. time= 319.0 min (1,076.2 - 757.2)

Volume	Invert	Avail.Storage	Storage Description
#1A	101.00'	22,505 cf	76.00'W x 170.00'L x 9.00'H Field A 116,280 cf Overall - 60,017 cf Embedded = 56,263 cf x 40.0% Voids
#2A	101.50'	60,017 cf	CMP Round 96 x 56 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 56 Chambers in 7 Rows 74.00' Header x 50.27 sf x 1 = 3,719.6 cf Inside
		82,522 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	101.50'	**12.0" Round Culvert** L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 101.50' / 99.50' S= 0.0200 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Discarded	101.00'	**2.410 in/hr Exfiltration over Surface area**
#3	Device 1	102.50'	**4.0" Vert. Orifice/Grate** C= 0.600
#4	Device 1	107.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.72 cfs @ 8.45 hrs HW=101.09' (Free Discharge)
└2=**Exfiltration** (Exfiltration Controls 0.72 cfs)

Primary OutFlow Max=0.85 cfs @ 14.10 hrs HW=106.78' (Free Discharge)
└1=**Culvert** (Passes 0.85 cfs of 6.53 cfs potential flow)
  ├3=**Orifice/Grate** (Orifice Controls 0.85 cfs @ 9.76 fps)
  └4=**Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)
Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf
Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

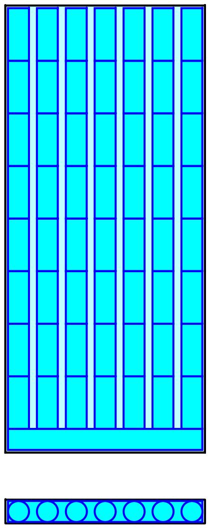
8 Chambers/Row x 20.00' Long +8.00' Header x 1 = 168.00' Row Length +12.0" End Stone x 2 = 170.00' Base Length
7 Rows x 96.0" Wide + 36.0" Spacing x 6 + 12.0" Side Stone x 2 = 76.00' Base Width
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

56 Chambers x 1,005.3 cf + 74.00' Header x 50.27 sf = 60,017.0 cf Chamber Storage

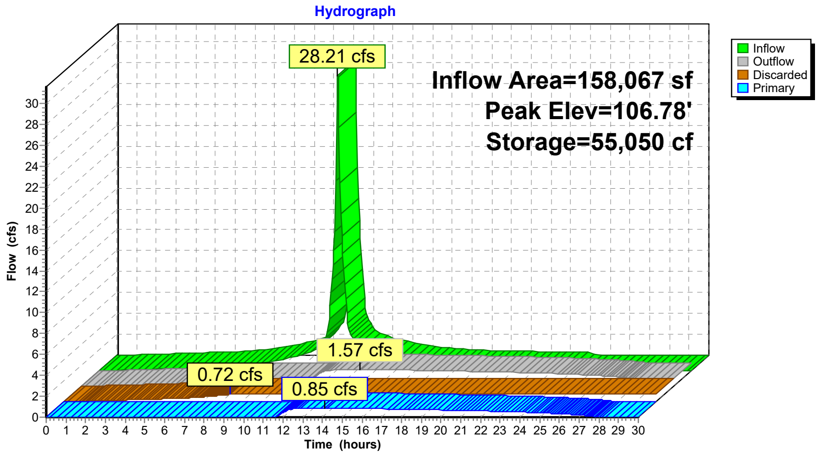
116,280.0 cf Field - 60,017.0 cf Chambers = 56,263.0 cf Stone x 40.0% Voids = 22,505.2 cf Stone Storage

Chamber Storage + Stone Storage = 82,522.2 cf = 1.894 af
Overall Storage Efficiency = 71.0%
Overall System Size = 170.00' x 76.00' x 9.00'

56 Chambers
4,306.7 cy Field
2,083.8 cy Stone



Pond UIS-1: UIS-1 - Southwest Lawn (96" CMP)

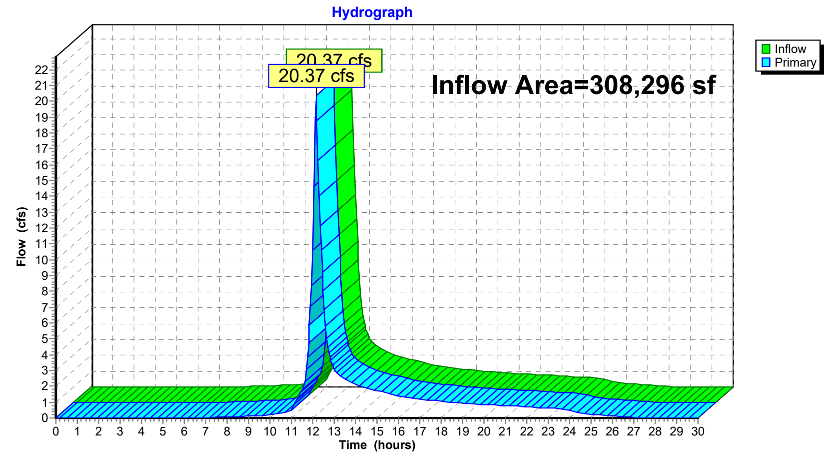


Summary for Link SP-1: Study Point #1

Inflow Area = 308,296 sf, 44.54% Impervious, Inflow Depth = 3.73" for 100-Year event
Inflow = 20.37 cfs @ 12.15 hrs, Volume= 95,906 cf
Primary = 20.37 cfs @ 12.15 hrs, Volume= 95,906 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1

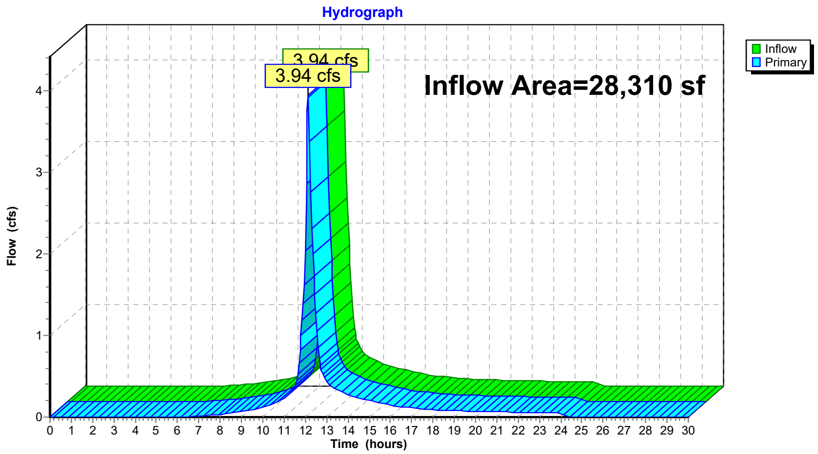


Summary for Link SP-2: Study Point #2

Inflow Area = 28,310 sf, 0.00% Impervious, Inflow Depth = 6.01" for 100-Year event
Inflow = 3.94 cfs @ 12.14 hrs, Volume= 14,186 cf
Primary = 3.94 cfs @ 12.14 hrs, Volume= 14,186 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2

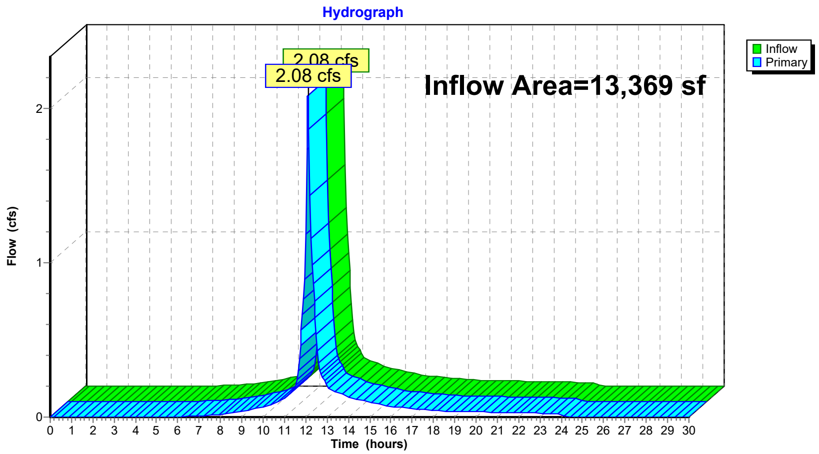


Summary for Link SP-3: Study Point #3

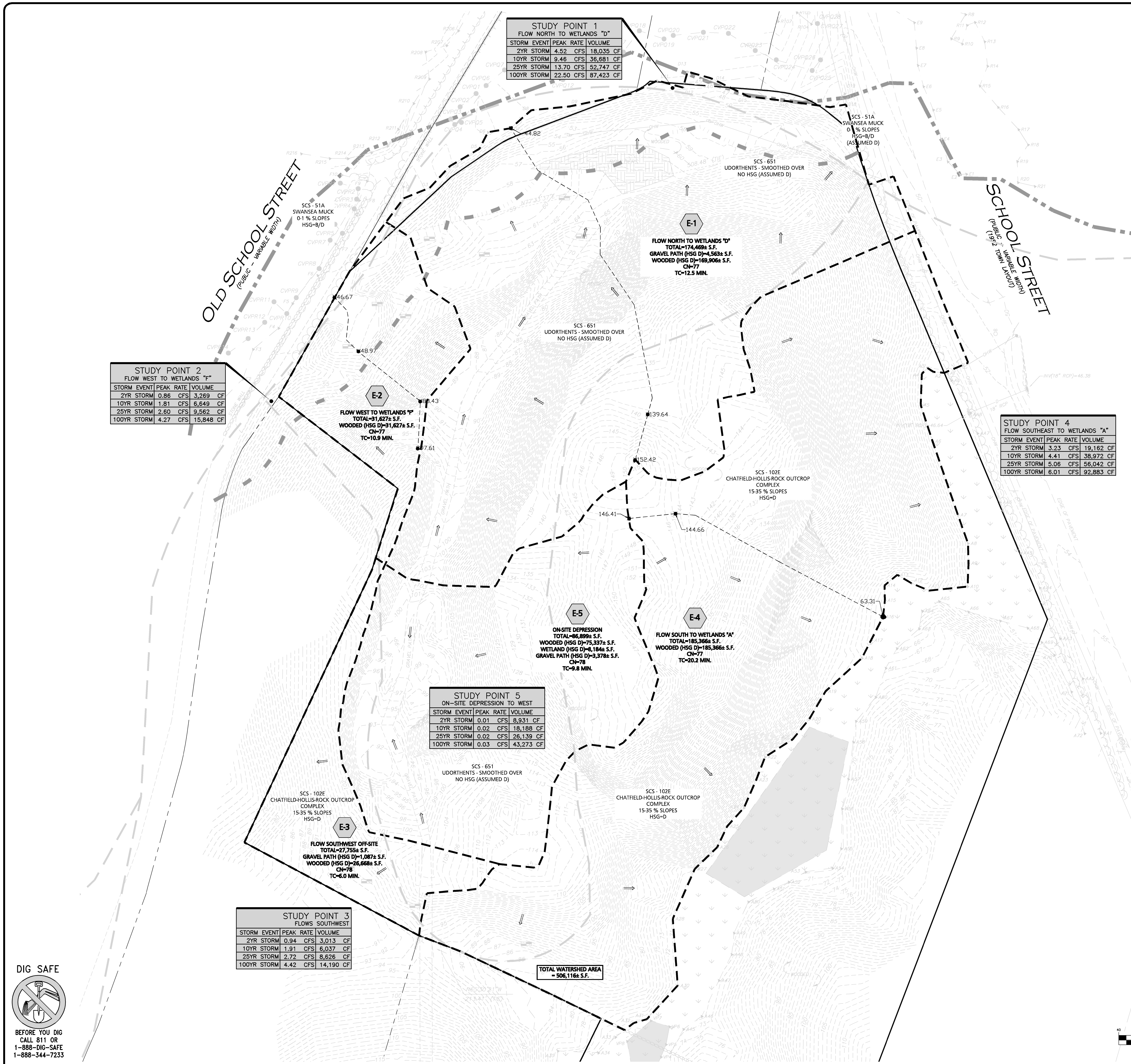
Inflow Area = 13,369 sf, 4.23% Impervious, Inflow Depth = 6.26" for 100-Year event
Inflow = 2.08 cfs @ 12.11 hrs, Volume= 6,971 cf
Primary = 2.08 cfs @ 12.11 hrs, Volume= 6,971 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



SECTION 5.0 – PLANS



STUDY POINT 1
FLOW NORTH TO WETLANDS "D"

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	4.52 CFS	18,035 CF
10YR STORM	9.46 CFS	36,681 CF
25YR STORM	13.70 CFS	52,747 CF
100YR STORM	22.50 CFS	87,423 CF

STUDY POINT 2
FLOW WEST TO WETLANDS "F"

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	0.86 CFS	3,269 CF
10YR STORM	1.81 CFS	6,649 CF
25YR STORM	2.60 CFS	9,562 CF
100YR STORM	4.27 CFS	15,848 CF

STUDY POINT 3
FLOWS SOUTHWEST

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	0.94 CFS	3,013 CF
10YR STORM	1.91 CFS	6,037 CF
25YR STORM	2.72 CFS	8,626 CF
100YR STORM	4.42 CFS	14,190 CF

STUDY POINT 4
FLOW SOUTHEAST TO WETLANDS "A"

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	3.23 CFS	19,162 CF
10YR STORM	4.41 CFS	38,972 CF
25YR STORM	5.06 CFS	56,042 CF
100YR STORM	6.01 CFS	92,883 CF

STUDY POINT 5
ON-SITE DEPRESSION TO WEST

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	0.01 CFS	8,931 CF
10YR STORM	0.02 CFS	18,188 CF
25YR STORM	0.02 CFS	26,139 CF
100YR STORM	0.03 CFS	43,273 CF

LEGEND

- EXISTING WATERSHED
- SCS SOILS BOUNDARY
- Tc FLOW PATH (A — B)
- SUBCATCHMENT LABEL (E-1)
- SUBCATCHMENT BOUNDARY
- FLOW DIRECTION

NOTES:

1. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY AND HAVE NOT BEEN INDEPENDENTLY VERIFIED BY THE OWNER OR IT'S REPRESENTATIVE. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK, AND AGREES TO BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE OCCASIONED BY THE CONTRACTOR'S FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.
2. THE INFORMATION SHOWN ON THIS PLAN IS THE SOLE PROPERTY OF ALLEN & MAJOR ASSOCIATES, INC. ITS INTENDED USE IS TO PROVIDE INFORMATION. ANY ALTERATION, MISUSE, OR RECALCULATION OF INFORMATION OR DATA WITHOUT THE EXPRESSED, WRITTEN CONSENT OF ALLEN & MAJOR ASSOCIATES, INC. IS STRICTLY PROHIBITED.
3. BASE PLAN TAKEN FROM PLAN ENTITLED "EXISTING CONDITIONS, SHEETS V-101 & V-102" PREPARED BY ALLEN & MAJOR ASSOCIATES, REVISED THROUGH MAY 27, 2021 ORIGINAL SCALE 1"=50'.
4. ALL EXISTING AND PROPOSED COVER TYPES SHALL BE CONSIDERED "GOOD" FOR MODELING PURPOSES UNLESS OTHERWISE NOTED.
5. TOTAL SITE WATERSHED AREA IS 506,116± S.F.

DIG SAFE
BEFORE YOU DIG
CALL 811 OR
1-888-DIG-SAFE
1-888-344-7233

GRAPHIC SCALE
40 0 20 40 80 160
(IN FEET)
1 inch = 40 ft.

N:\PROJECTS\2725-01\CIVIL\DRAWINGS\CURRENT\C-2725-01_WATERSHED-EXISTING.DWG

ISSUED FOR
DRAINAGE REPORT
MARCH 22, 2022

PROFESSIONAL ENGINEER FOR
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION
A	03-23-2022	REVISED PER COMMENTS

APPLICANT\OWNER:

SLV SCHOOL STREET, LLC
257 HILLSIDE AVENUE
NEEDHAM, MA 02494

PROJECT:

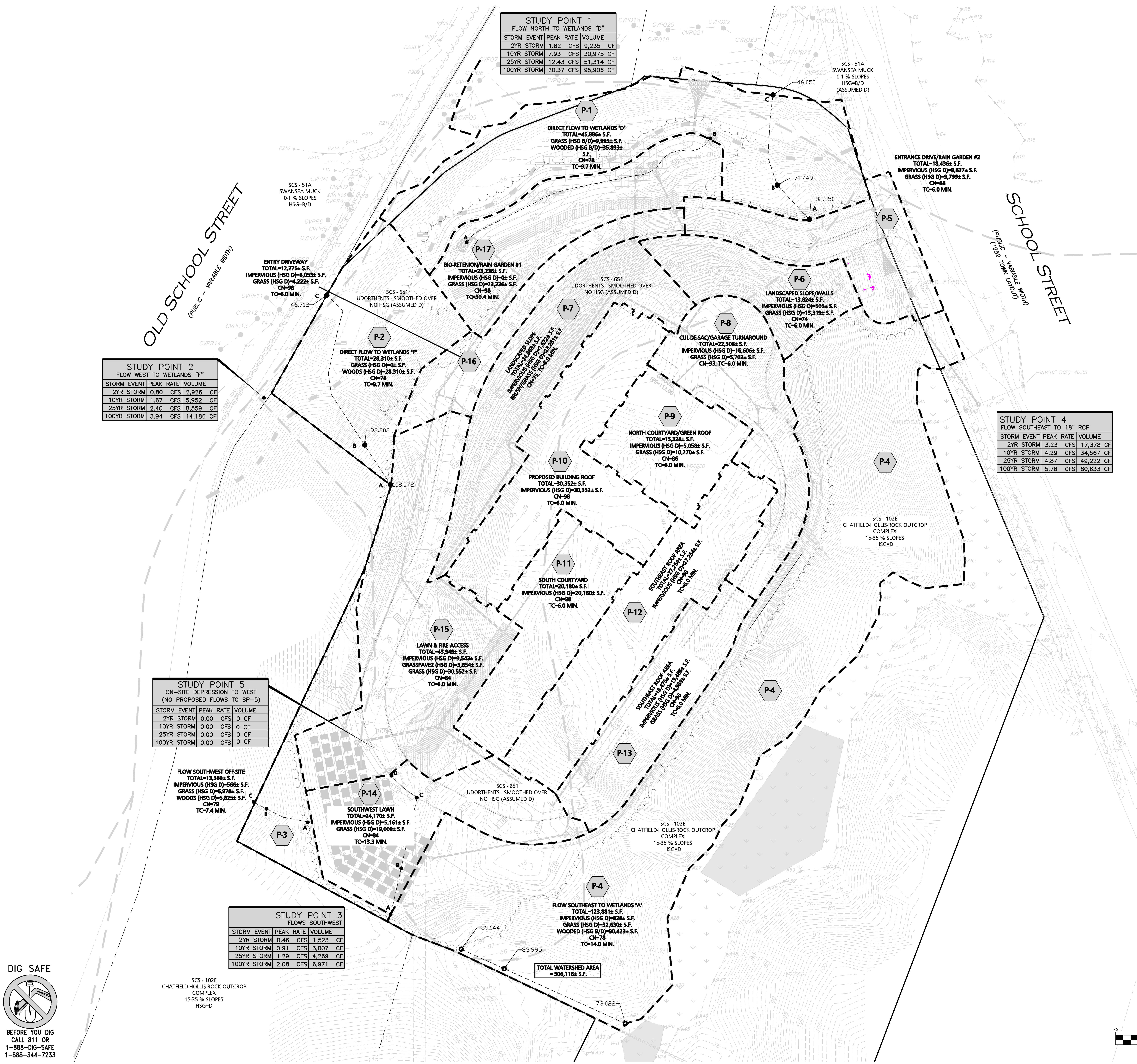
THE SANCTUARY
SCHOOL STREET
MANCHESTER-BY-THE-SEA, MA

PROJECT NO.	2725-01	DATE:	07-16-2021
SCALE:	1"=40'	DWG. NAME:	C-2725-01
DESIGNED BY:	CMQ/SJL	CHECKED BY:	CMQ

PREPARED BY:
ALLEN & MAJOR ASSOCIATES, INC.
civil engineering ◆ land surveying
environmental consulting ◆ landscape architecture
www.allenmajor.com
100 COMMERCE WAY, SUITE 5
WOBURN MA 01801-8501
TEL: (781) 935-6889
FAX: (781) 935-2896
WOBURN, MA ◆ LAKEVILLE, MA ◆ MANCHESTER, NH

DRAWING TITLE: EXISTING WATERSHED PLAN

SHEET No. EWS-1



STUDY POINT 1
FLOW NORTH TO WETLANDS "D"

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	1.82 CFS	9,235 CF
10YR STORM	7.93 CFS	30,975 CF
25YR STORM	12.43 CFS	51,314 CF
100YR STORM	20.37 CFS	95,906 CF

STUDY POINT 2
FLOW WEST TO WETLANDS "F"

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	0.80 CFS	2,926 CF
10YR STORM	1.67 CFS	5,952 CF
25YR STORM	2.40 CFS	8,559 CF
100YR STORM	3.94 CFS	14,186 CF

STUDY POINT 3
FLOWS SOUTHWEST

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	0.46 CFS	1,523 CF
10YR STORM	0.91 CFS	3,007 CF
25YR STORM	1.29 CFS	4,269 CF
100YR STORM	2.08 CFS	6,971 CF

STUDY POINT 4
FLOW SOUTHEAST TO 18" RCP

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	3.23 CFS	17,378 CF
10YR STORM	4.29 CFS	34,567 CF
25YR STORM	4.87 CFS	49,222 CF
100YR STORM	5.78 CFS	80,633 CF

STUDY POINT 5
ON-SITE DEPRESSION TO WEST
(NO PROPOSED FLOWS TO SP-5)

STORM EVENT	PEAK RATE	VOLUME
2YR STORM	0.00 CFS	0 CF
10YR STORM	0.00 CFS	0 CF
25YR STORM	0.00 CFS	0 CF
100YR STORM	0.00 CFS	0 CF

LEGEND

- EXISTING WATERSHED
- PROPOSED WATERSHED
- SCS SOILS BOUNDARY
- Tc FLOW PATH
- SUBCATCHMENT LABEL
- SUBCATCHMENT BOUNDARY
- FLOW DIRECTION

NOTES:

1. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY AND HAVE NOT BEEN INDEPENDENTLY VERIFIED BY THE OWNER OR IT'S REPRESENTATIVE. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK, AND AGREES TO BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE OCCASIONED BY THE CONTRACTOR'S FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.
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3. BASE PLAN TAKEN FROM PLAN ENTITLED "EXISTING CONDITIONS, SHEETS V–101 & V–102" PREPARED BY ALLEN & MAJOR ASSOCIATES, REVISED THROUGH MAY 27, 2021 ORIGINAL SCALE 1"=50'.
4. ALL EXISTING AND PROPOSED COVER TYPES SHALL BE CONSIDERED "GOOD" FOR MODELING PURPOSES UNLESS OTHERWISE NOTED.
5. TOTAL SITE WATERSHED AREA IS 506,116± S.F.

ISSUED FOR DRAINAGE REPORT
MARCH 23, 2022

PROFESSIONAL ENGINEER FOR
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION
A	03-23-2022	REVISED PER COMMENTS

APPLICANT\OWNER:
SLV SCHOOL STREET, LLC
257 HILLSIDE AVENUE
NEEDHAM, MA 02494

PROJECT:
THE SANCTUARY
SCHOOL STREET
MANCHESTER-BY-THE-SEA, MA

PROJECT NO.	2725-01	DATE:	07-16-2021
SCALE:	1"=40'	DWG. NAME:	C-2725-01
DESIGNED BY:	CMQ/SJL	CHECKED BY:	CMQ

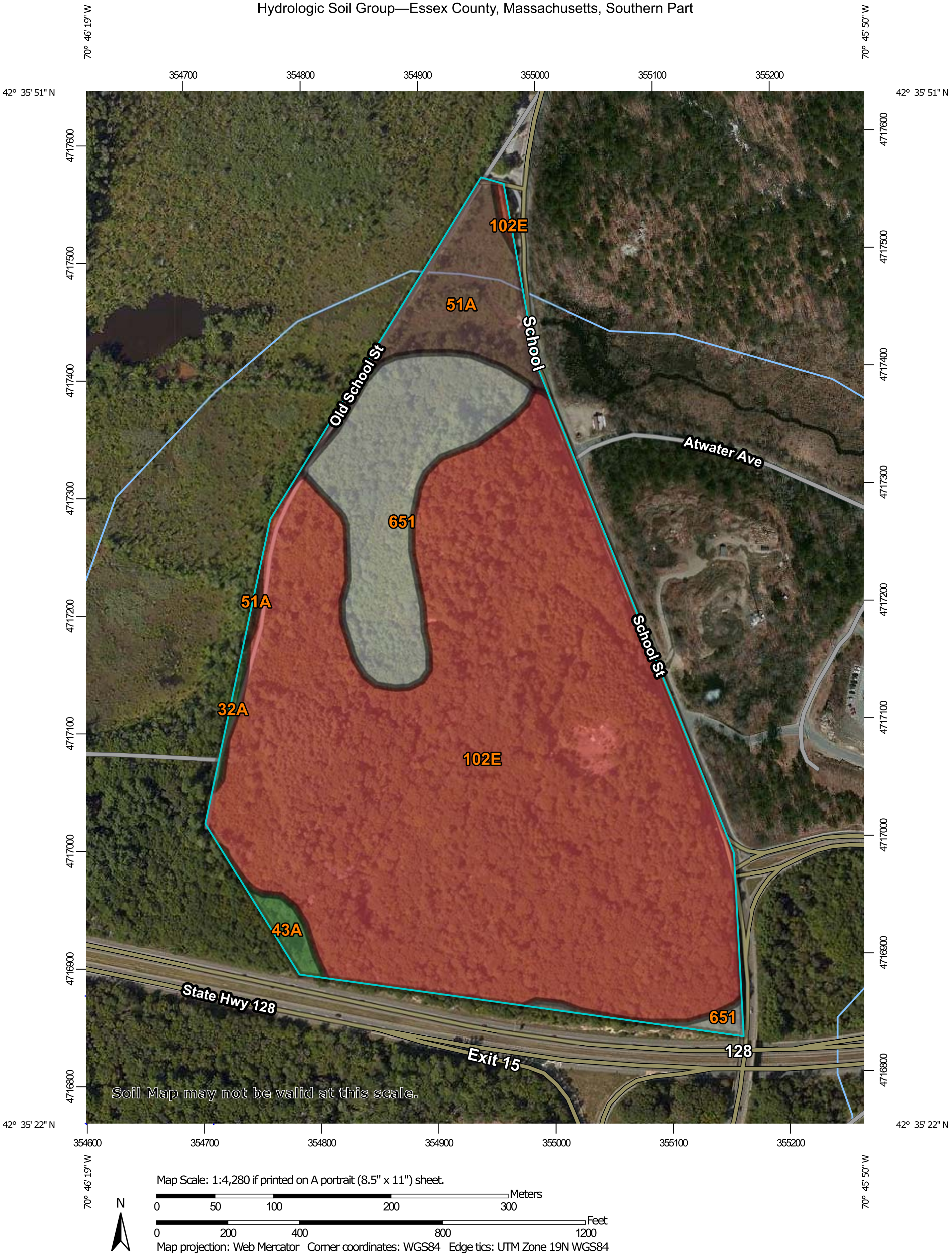
PREPARED BY:
ALLEN & MAJOR ASSOCIATES, INC.
civil engineering ◆ land surveying
environmental consulting ◆ landscape architecture
www.allenmajor.com
100 COMMERCE WAY, SUITE 5
WOBURN MA 01801-8501
TEL: (781) 935-6889
FAX: (781) 935-2896
WOBURN, MA ◆ LAKEVILLE, MA ◆ MANCHESTER, NH

DRAWING TITLE: PROPOSED WATERSHED PLAN

SHEET No. PWS-1

N:\PROJECTS\2725-01\CIVIL\DRAWINGS\CURRENT\C-2725-01_WATERSHED-PROPOSED.DWG

SECTION 6.0 - APPENDIX


70° 46' 19" W
70° 45' 50" W
354700
354800
354900
355000
355100
355200
42° 35' 51" N
42° 35' 51" N
4717600
4717500
4717400
4717300
4717200
4717100
4717000
4716900
4716800
102E
51A
School
Old School St
Atwater Ave
651
School St
51A
32A
102E
43A
State Hwy 128
651
128
Exit 15
Soil Map may not be valid at this scale.
42° 35' 22" N
42° 35' 22" N
354600
354700
354800
354900
355000
355100
355200
70° 46' 19" W
70° 45' 50" W
Map Scale: 1:4,280 if printed on A portrait (8.5" x 11") sheet.
N
0 50 100 200 300 Meters
0 200 400 800 1200 Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

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

Soil Rating Lines

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

Soil Rating Points

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

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

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

Soil Survey Area: Essex County, Massachusetts, Southern Part
Survey Area Data: Version 17, Jun 9, 2020

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

Date(s) aerial images were photographed: Mar 30, 2011—Sep 19, 2014

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
32A	Wareham loamy sand, 0 to 3 percent slopes	A/D	0.2	0.3%
43A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	A/D	0.5	1.0%
51A	Swansea muck, 0 to 1 percent slopes	B/D	3.3	6.7%
102E	Chatfield-Hollis-Rock outcrop complex, 15 to 35 percent slopes	D	38.5	78.8%
651	Udorthents, smoothed		6.4	13.1%
Totals for Area of Interest			**48.9**	**100.0%**

Description

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

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

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

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

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

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

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

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

A. Facility Information

Owner Name

0 Old School Street — Street Address
Map 43 Lot 0 18 — Map/Lot #

Manchester by the Sea — City
MA — State
01944 — Zip Code

B. Site Information

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

2. Soil Survey Available? ☒ Yes ☐ No If yes: UC Davis NRCS (Source) 102E (Soil Map Unit)

   Chatfield-Hollis-Rock Outcrop — Soil Name
   High runoff — Soil Limitations

   Glacial Till, coarse-loamy melt-out till derived from granite, gneiss, and/or schist
   Shoulder — Landform

3. Surficial Geological Report Available? ☐ Yes ☐ No If yes: MassGIS (Year Published/Source) Till/Bedrock (Map Unit)

   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: NA (Wetland Type)

7. Current Water Resource Conditions (USGS): 11/30/2020 (Month/Day/ Year) Range: ☒ Above Normal ☐ Normal ☐ Below Normal

8. Other references reviewed: Station 423506070491401, MA-WPW 76R, Wenham, MA

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE-TP-1 (Hole #) 11-18-2020 (Date) AM (Time) Sunny (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Trees, light underbrush (Vegetation) Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 3-8% (Slope (%))

   Description of Location: ______

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

3. Distances from: Open Water Body >100 feet Drainage Way >10 feet Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-3	A										
3-16	Bw	Loamy Sand	10 YR 5/6				2	0	Massive	Very Friable	Roots to 16"
16-120	C	Loamy Sand	10 YR 4/4				10	10	Massive	Very Friable	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: Obs. Hole #1 Obs. Hole #

☒ Depth observed standing water in observation hole — None inches — _____ inches

☒ Depth weeping from side of observation hole — None inches — _____ inches

☐ Depth to soil redoximorphic features (mottles) — _____ inches — _____ inches

☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology) — _____ inches — _____ 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: 120"+ 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: 3 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE-TP-2 (Hole #) 11-18-2020 (Date) AM (Time) Sunny (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Trees, light underbrush (Vegetation) Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 3-8% (Slope (%))

   Description of Location: ______

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

3. Distances from: Open Water Body >100 feet Drainage Way >10 feet Wetlands >50 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: NA Depth Weeping from Pit NA 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										
4-23	Bw	Loamy Sand	10 YR 5/6					2	Massive	Very Friable	
23-120	C	Loamy Sand	10 YR 5/4				10		Massive	Very Friable	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: Obs. Hole # 2 Obs. Hole # ____

	Obs. Hole # 2	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	______ inches
☒ Depth weeping from side of observation hole	None inches	______ inches
☐ Depth to soil redoximorphic features (mottles)	______ inches	______ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	______ inches	______ 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: 120"+ 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: 4 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE-TP-3 (Hole #) 11-18-2020 (Date) AM (Time) Sunny (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) — Trees, light underbrush (Vegetation) — Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) — 3-8% (Slope (%))

   Description of Location: ______

2. Soil Parent Material: Glacial Till — Kame (Landform) — SH (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >100 feet; Drainage Way >10 feet; Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-6	A										
6-18	Bw	Loamy Sand	10 YR 5/8					2	Massive	Very Friable	
23-120	C	Loamy Sand	10 YR 5/4				30	10	Massive	Very Friable	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used:

	Obs. Hole #3	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	_____ inches
☒ Depth weeping from side of observation hole	None inches	_____ inches
☐ Depth to soil redoximorphic features (mottles)	_____ inches	_____ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	_____ 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: 120"+ 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: 6 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE-TP-4 (Hole #) | 11-18-2020 (Date) | AM (Time) | Sunny (Weather) | ______ (Latitude) | ______ (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Trees, light underbrush (Vegetation) | Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 3-8% (Slope (%))

   Description of Location: ______

2. Soil Parent Material: Glacial Till | Kame (Landform) | SH (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >100 feet | Drainage Way >10 feet | Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-5	A										
5-18	Bw	Fine Loamy Sand	10 YR 5/8					2	Massive	Very Friable	Roots to 18”
18-120	C	Loamy Sand	10 YR 5/4				10		Massive	Very Friable	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: Obs. Hole #4 | Obs. Hole #

- ☒ Depth observed standing water in observation hole — None inches | _____ inches
- ☒ Depth weeping from side of observation hole — None inches | _____ inches
- ☐ Depth to soil redoximorphic features (mottles) — _____ inches | _____ inches
- ☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology) — _____ inches | _____ 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: 120"+ 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: 5 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE-TP-5 (Hole #) 11-18-2020 (Date) AM (Time) Sunny (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Trees, light underbrush (Vegetation) Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 3-8% (Slope (%))

   Description of Location: ______

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

3. Distances from: Open Water Body >100 feet Drainage Way >10 feet Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-3	A										
3-22	Bw	Loamy Sand	10 YR 5/6						Massive	Very Friable	
22-120	C	Loamy Sand	10 YR 5/4				10	10	Massive	Firm in Place, Friable in hand	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: | Obs. Hole # 5 | Obs. Hole #

Method	Obs. Hole # 5	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	______ inches
☒ Depth weeping from side of observation hole	None inches	______ inches
☐ Depth to soil redoximorphic features (mottles)	______ inches	______ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	______ inches	______ 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: 120"+ 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: 3 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE-TP-6 (Hole #) 11-18-2020 (Date) PM (Time) Sunny (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Trees, light underbrush (Vegetation) Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 3-8% (Slope (%))

   Description of Location: ______

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

3. Distances from: Open Water Body >100 feet Drainage Way >10 feet Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-3	A										
3-24	Bw	Loamy Sand	10 YR 5/6						Massive	Very Friable	
24-120	C	Loamy Sand	10 YR 5/4					2	Massive	Firm in Place, Friable in hand	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: Obs. Hole # 6 | Obs. Hole # ____

	Obs. Hole # 6	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	____ inches
☒ Depth weeping from side of observation hole	None inches	____ inches
☐ Depth to soil redoximorphic features (mottles)	____ inches	____ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	____ inches	____ 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: 120"+ 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: 3 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE TP-7 (Hole #) 11-18-2020 (Date) PM (Time) Sunny (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Trees, light underbrush (Vegetation) Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 3-8% (Slope (%))

   Description of Location: ____________________

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

3. Distances from: Open Water Body >100 feet Drainage Way >10 feet Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-5	A										
5-17	Bw	Loamy Sand	10 YR 5/4						Massive	Very Friable	
17-120	C	Loamy Sand	10 YR 4/6					2	Massive	Firm in Place, Friable in hand	Isolated pockets of Medium to Coarse Sand

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used:

	Obs. Hole # 7	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	_____ inches
☒ Depth weeping from side of observation hole	None inches	_____ inches
☐ Depth to soil redoximorphic features (mottles)	_____ inches	_____ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	_____ 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: 120"+ 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: 5 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE TP-8 (Hole #) | 11-18-2020 (Date) | PM (Time) | Sunny (Weather) | ______ (Latitude) | ______ (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Trees, light underbrush (Vegetation) | Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 3-8% (Slope (%))

   Description of Location: ______

2. Soil Parent Material: Glacial Till | Kame (Landform) | SH (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >100 feet | Drainage Way >10 feet | Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-7	A										
7-17	Bw	Loamy Sand	10 YR 5/6						Massive	Very Friable	
17-67	C	Loamy Sand	10 YR 5/4					2	Massive	Firm in Place, Friable in hand	Ledge at 67"

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: — Obs. Hole # 8 — Obs. Hole # ____

Method	Obs. Hole # 8	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	____ inches
☒ Depth weeping from side of observation hole	None inches	____ inches
☐ Depth to soil redoximorphic features (mottles)	____ inches	____ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	____ inches	____ 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: 120"+ 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: 7 inches Lower boundary: 67 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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.

Paul Ruszala (signature)	12-2-2020
Signature of Soil Evaluator	Date
Paul Ruszala, License #14111	6/30/2023
Typed or Printed Name of Soil Evaluator / License #	Expiration Date of License
Paul Blain	MassDEP
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:

Test pits will be field surveyed and shown on the effluent disposal system design plans.

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

Percolation Test

Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name:

Street Address or Lot #: 0 Old School Street

City/Town: Manchester by the Sea

State: MA

Zip Code: 01944

Contact Person (if different from Owner):

Telephone Number:

B. Test Results

Date / Time	11-18-2020 / 9:48 AM	
Observation Hole #	OSE TP-1	
Depth of Perc	32"	
Start Pre-Soak	9:48 AM	
End Pre-Soak	10:03 AM	
Time at 12”	10:03 AM	
Time at 9”	10:10 AM	
Time at 6”	10:18 AM	
Time (9”-6”)	8 minutes	
Rate (Min./Inch)	3 minutes/inch	
	Test Passed: ☒ Test Failed: ☐	Test Passed: ☐ Test Failed: ☐

Test Performed By: Raymond Willis, P.E.

Board of Health Witness: Paul Blain, MassDEP

Comments:

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

Percolation Test

Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name:

Street Address or Lot #: 0 Old School Street

City/Town	State	Zip Code
Manchester by the Sea	MA	01944

Contact Person (if different from Owner):

Telephone Number:

B. Test Results

	Date	Time	Date	Time
	11-18-2020	11:14 AM		
Observation Hole #	OSE TP-2			
Depth of Perc	32"			
Start Pre-Soak	11:14 AM			
End Pre-Soak	11:29 AM			
Time at 12”	11:29 AM			
Time at 9”	11:35 AM			
Time at 6”	11:41 AM			
Time (9”-6”)	6 minutes			
Rate (Min./Inch)	2 minutes/inch			
	Test Passed: ☒		Test Passed: ☐	
	Test Failed: ☐		Test Failed: ☐	

Test Performed By: Raymond Willis, P.E.

Board of Health Witness: Paul Blain, MassDEP

Comments:

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

Percolation Test

Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name:

Street Address or Lot #: 0 Old School Street

City/Town: Manchester by the Sea | State: MA | Zip Code: 01944

Contact Person (if different from Owner):

Telephone Number:

B. Test Results

	Date: 11-18-2020	Time: 2:17 PM	Date:	Time:
Observation Hole #	OSE TP-5			
Depth of Perc	48"			
Start Pre-Soak	2:17 PM			
End Pre-Soak	2:32 PM			
Time at 12”	2:32 PM			
Time at 9”	2:54 PM			
Time at 6”	3:19 PM			
Time (9”-6”)	25 minutes			
Rate (Min./Inch)	8.3 minutes/inch			
	Test Passed: ☒		Test Passed: ☐	
	Test Failed: ☐		Test Failed: ☐	

Test Performed By: Raymond Willis, P.E.

Board of Health Witness: Paul Blain, MassDEP

Comments:

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

A. Facility Information

Owner Name

0 Old School Street
Street Address

Map 43 Lot 0 18
Map/Lot #

Manchester by the Sea
City

MA
State

01944
Zip Code

B. Site Information

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

2. Soil Survey Available? ☒ Yes ☐ No If yes: UC Davis NRCS (Source) 102E (Soil Map Unit)

   Chatfield-Hollis-Rock Outcrop
   Soil Name

   High runoff
   Soil Limitations

   Glacial Till, coarse-loamy melt-out till derived from granite, gneiss, and/or schist

   Shoulder
   Landform

3. Surficial Geological Report Available? ☐ Yes ☐ No If yes: MassGIS (Year Published/Source) Till/Bedrock (Map Unit)

   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: NA (Wetland Type)

7. Current Water Resource Conditions (USGS): 11/30/2020 (Month/Day/ Year) Range: ☒ Above Normal ☐ Normal ☐ Below Normal

8. Other references reviewed: Station 423506070491401, MA-WPW 76R, Wenham, MA

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE TP-9 (Hole #) 11-19-2020 (Date) AM (Time) Sunny (Weather) ______ (Latitude) ______ (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Trees, light underbrush (Vegetation) Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 3-8% (Slope (%))

   Description of Location: ______

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

3. Distances from: Open Water Body >100 feet Drainage Way >10 feet Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-6	A										
6-28	Bw	Loamy Sand	10 YR 5/6						Massive	Very Friable	Roots to 28"
28-120	C	Loamy Sand	10 YR 5/4				10		Massive	Firm in Place, Friable in hand	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: Obs. Hole # 9 | Obs. Hole # ____

Method	Obs. Hole # 9	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	_____ inches
☒ Depth weeping from side of observation hole	None inches	_____ inches
☐ Depth to soil redoximorphic features (mottles)	_____ inches	_____ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	_____ 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: 120"+ 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: 6 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE TP-10 | 11-19-2020 Date | AM Time | Sunny Weather | ______ Latitude | ______ Longitude:

1. Land Use Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Trees, light underbrush Vegetation | Some Surface Stones (e.g., cobbles, stones, boulders, etc.) | 3-8% Slope (%)

   Description of Location: ______

2. Soil Parent Material: Glacial Till | Kame Landform | SH Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body >100 feet | Drainage Way >10 feet | Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-5	A										
5-26	Bw	Loamy Sand	10 YR 5/6						Massive	Very Friable	
26-120	C	Loamy Sand	10 YR 5/4				2		Massive	Firm in Place, Friable in hand	

Additional Notes:
No water, no mottles, no redox

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

D. Determination of High Groundwater Elevation

1. Method Used: Obs. Hole # 10 Obs. Hole #

Method	Obs. Hole # 10	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	_____ inches
☒ Depth weeping from side of observation hole	None inches	_____ inches
☐ Depth to soil redoximorphic features (mottles)	_____ inches	_____ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	_____ 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: 120"+ 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: 5 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE TP-11 | 11-19-2020 Date | AM Time | Sunny Weather | ____ Latitude | ____ Longitude:

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Trees, light underbrush Vegetation | Some Surface Stones (e.g., cobbles, stones, boulders, etc.) | 3-8% Slope (%)

   Description of Location: ____________________

2. Soil Parent Material: Glacial Till | Kame Landform | SH Position on Landscape (SU, SH, BS, FS, TS)

3. Distances from: Open Water Body >100 feet | Drainage Way >10 feet | Wetlands >50 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: NA Depth Weeping from Pit NA 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			
0-3	A										
3-23	Bw	Loamy Sand	10 YR 5/6						Massive	Very Friable	
32-58	C	Loamy Sand	10 YR 5/4				2	15	Massive	Firm in Place, Friable in hand	Ledge at 58”

Additional Notes:
No water, no mottles, no redox

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

D. Determination of High Groundwater Elevation

1. Method Used: Obs. Hole # 11 | Obs. Hole # ____

- ☒ Depth observed standing water in observation hole: None inches | ____ inches
- ☒ Depth weeping from side of observation hole: None inches | ____ inches
- ☐ Depth to soil redoximorphic features (mottles): ____ inches | ____ inches
- ☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology): ____ inches | ____ 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: 120"+ 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: 3 inches Lower boundary: 58 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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: OSE TP-12 | 11-19-2020 (Date) | AM (Time) | Sunny (Weather) | ______ (Latitude) | ______ (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | Trees, light underbrush (Vegetation) | Some (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 3-8% (Slope (%))

   Description of Location: ______

2. Soil Parent Material: Glacial Till | Kame (Landform) | SH (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >100 feet | Drainage Way >10 feet | Wetlands >50 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: NA Depth Weeping from Pit NA 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										
4-17	Bw	Loamy Sand	10 YR 5/6						Massive	Very Friable	
17-120	C	Loamy Sand	10 YR 5/4				2	15	Massive	Firm in Place, Friable in hand	

Additional Notes:
No water, no mottles, no redox

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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

D. Determination of High Groundwater Elevation

1. Method Used: | Obs. Hole # 12 | Obs. Hole #

Method	Obs. Hole # 12	Obs. Hole #
☒ Depth observed standing water in observation hole	None inches	______ inches
☒ Depth weeping from side of observation hole	None inches	______ inches
☐ Depth to soil redoximorphic features (mottles)	______ inches	______ inches
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	______ inches	______ 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: 120"+ 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: 4 inches Lower boundary: 120 inches

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

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

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.

Paul Ruszala (signature)	12-2-2020
Signature of Soil Evaluator	Date
Paul Ruszala, License #14111	6/30/2023
Typed or Printed Name of Soil Evaluator / License #	Expiration Date of License
Paul Blain	MassDEP
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:

Test pits will be field surveyed and shown on the effluent disposal system design plans.

Commonwealth of Massachusetts
City/Town of Manchester by the Sea

Percolation Test

Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name:

Street Address or Lot #: 0 Old School Street

City/Town: Manchester by the Sea | State: MA | Zip Code: 01944

Contact Person (if different from Owner): | Telephone Number:

B. Test Results

	Date: 11-19-2020 / Time: 9:11 AM	Date: / Time:
Observation Hole #	OSE TP-9	
Depth of Perc	34"	
Start Pre-Soak	9:11 AM	
End Pre-Soak	9:26 AM	
Time at 12”	9:26 AM	
Time at 9”	9:41 AM	
Time at 6”	9:56 AM	
Time (9”-6”)	15 minutes	
Rate (Min./Inch)	5 minutes/inch	
	Test Passed: ☒ Test Failed: ☐	Test Passed: ☐ Test Failed: ☐

Test Performed By: Raymond Willis, P.E.

Board of Health Witness: Paul Blain, MassDEP

Comments:

Commonwealth of Massachusetts
City/Town of Manchester by the Sea
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name:

Street Address or Lot #: 0 Old School Street

City/Town	State	Zip Code
Manchester by the Sea	MA	01944

Contact Person (if different from Owner):

Telephone Number:

B. Test Results

	Date	Time	Date	Time
	11-19-2020	10:58 AM		
Observation Hole #	OSE TP-12			
Depth of Perc	34"			
Start Pre-Soak	10:58 AM			
End Pre-Soak	11:13 AM			
Time at 12"	11:13 AM			
Time at 9"	11:31 AM			
Time at 6"	11:49 AM			
Time (9"-6")	18 minutes			
Rate (Min./Inch)	6			
	Test Passed: ☒		Test Passed: ☐	
	Test Failed: ☐		Test Failed: ☐	

Test Performed By: Raymond Willis, P.E.

Board of Health Witness: Paul Blain, MassDEP

Comments:

Via email: gengler@s-e-b.com; cquinn@allenmajor.com

July 29, 2020

Mr. Geoffrey Engler
SLV SCHOOL STREET, LLC
257 Hillside Avenue
Needham, Massachusetts 02494

RE: Geotechnical Reconnaissance
Proposed MBTS Apartments
School Street
Manchester-By-The-Sea, Massachusetts Project No. 20.119.NH

Dear Mr. Engler:

Miller Engineering & Testing, Inc. is pleased to submit this geotechnical reconnaissance report for the development proposed for the Lot 18 property on School Street in Manchester-By-The-Sea, Massachusetts (referred to as the "Site" in this report). This evaluation was completed in general accordance with our proposal, dated July 7, 2020 (Ref. File 220-20). The contents of this report are subject to the limitations in Attachment A.

1.0 Site and Proposed Development

The MBTS Apartments development is proposed for the northerly portion of Manchester parcel 43-0-18, with a street address of 0 School Street, in the northern side of Manchester-By-The-Sea, Massachusetts. Figure 1 of this report is a Site Location Map depicting the location of the Site on a 7.5-minute topographic quadrangle. Our current understanding of the existing conditions and the proposed Site layout and grades is based on examination of:

- "Site Concept Plan (Sheet A00), MBTS Apartments, Lot 18 – School Street, Manchester-By-The-Sea, MA" (dated 04/15/2020), as prepared by EMBARC Studio, LLC. of Boston, Massachusetts;
- "Grading & Drainage Plan (Sheet C-103), Exploratory Test Pit Activities, 0 School Street, Manchester-By-The-Sea, MA" (undated), as prepared by Allen & Major Associates, Inc. of Woburn, Massachusetts; and
- "Existing Conditions, Sheet V-101, Assessors Map 43, Lot 18, School Street, Manchester-By-The-Sea, MA" (dated 04/15/2020), also prepared by Allen & Major Associates, Inc. of Woburn, Massachusetts.

Review of the design plans from EMBARC and Allen & Major indicates that the MBTS Apartments would be a 4-story apartment complex with a one-level below-grade parking garage. The proposed development would have roadway access from School Street on an access driveway that would rise from approximate elevation 50 feet above Mean Sea Level (MSL) at School Street to the ground floor of the building at approximate elevation 125 feet MSL and the parking garage (slab elevation of 114 feet MSL).

2.0 Historical Information

Allen & Major encountered undocumented fill materials (possibly construction and demolition debris) in some of their test pits along the northerly side of the Site property (Figure 2). In order to determine the approximate time frame that the Site was used as a source of sand and gravel, and possibly filling, we obtained aerial photographs and satellite images from EDR, Inc. of Shelton, Connecticut and on-line historical topographic maps from the U.S. Geological Survey. These are included as Attachment B of this report. Examination of the historical maps and aerial photographs indicates:

- The westerly portion of the Site appears to have been operated as a sand and gravel pit from the 1960s to the 1980s.
- During that period, the Site had direct access to School Street; however, it appears that the primary access was from Old School Street.
- The 1969 photograph appeared to depict the maximum extent of the sand and gravel workings.
- By the time of the 1986 photograph, it appears that the Site was no longer used to provide sand and gravel, but may have been in use for disposal.
- Older aerial photographs (from 1938 and 1956) suggest that the Site had been explored for sand and gravel resources, but extensive extraction had not yet begun.
- The maps and aerial photographs did not depict any equipment or facilities (temporary or permanent) during the time the Site was used as a sand and gravel operation.
- Since the 1985 and 1986 images and maps, the Site has been revegetating into today's woodlands.

3.0 Site Reconnaissance

We performed a reconnaissance of the Site on 17 July 2020. Our observations are:

- There is an area of fill materials in the north side of the Site. The fills consisted chiefly of boulders and blocks of bedrock, possibly up to 5 feet thick. We also observed automobile parts, a heating oil tank, fragments of concrete slabs and asphalt pavements, and concrete blocks. Electric power was supplied to the Site by an overhead line that was observed on the ground but still connected to a pole on-site (pole #1-56/2). The fills appeared to resemble debris and construction wastes from small-scale roadway improvement projects.
- Topsoil is very thin, and averaged about 6 to 12 inches across the Site.
- The surficial, unconsolidated deposits consist of sand and gravel, probably directly overlying bedrock. The sand and gravel deposit contains an abundance of boulders, and most of the boulders are 3 to 5 feet in longest dimension (with some even larger).
- The sand and gravel deposit appears to have been deposited below elevation 140 feet MSL, based on the topography of the Site, features depicted on Allen & Major's

Existing Conditions Plan, and the extent of the sand and gravel workings that we observed.

- We observed bedrock exposures at the top of the hill; Site elevations higher than approximately 140 feet MSL are bedrock with a very thin layer of topsoil. Bedrock was also exposed at the north (low) end of the hill, at approximate elevations 55 to 65 feet MSL.

- We observed bedrock exposures at several nearby properties and along Route 128. At each, the rock had been blasted and excavated to reveal the rock structure. The bedrock exhibits a number of dominant fracture orientations that could control the breaking of the rock during blasting and the stability of rock-cut slopes.

- We did not observe water, either as surface waters or as groundwater seeps or discharges, during our reconnaissance.

4.0 Laboratory Testing

We collected bulk samples of the sand and gravel deposit soils from two locations at the Site within the former sand and gravel workings. Laboratory analyses indicate that the sand and gravel deposit is a well-graded soil (Unified Soil Classification System designations SP and SW, with a fines content (silt and clay fractions combined) of approximately 18 percent). The soil texture is a gravelly loamy sand, as determined using Natural Resource Conservation Service protocols (Attachment C).

5.0 Engineering Evaluation

Our visual observations and review of Allen & Major's test pits indicate that the Site is formed of 6 to 12 inches of topsoil overlying silty sand and gravel with shallow bedrock. The northwestern portion of the Site property is an area of fill materials, composed largely of boulders with some construction debris, that could be 5 to 6 feet thick in localized areas.

The silty sand and gravel soils appear to be exposed at the lower elevation portions of the Site (areas below approximately 140 feet MSL). We observed no indications of marine clay on the Site property; however, the adjacent lower lying wetlands could be underlain by soft marine clay deposits.

The bedrock is a coarse-grained alkali feldspar granite, which has been designated the "Cape Ann Granite" formation. This bedrock typically forms strong, near-vertical cuts when properly blasted and excavated using controlled (pre-split) techniques. However, location specific joint-sets will dictate the safe bedrock face slope angle that will minimize wedge, planer, and toppling failures.

6.0 Site Design Recommendations

Based on our visual observations and review of Site civil engineering plans, we present the following preliminary recommendations for the design of the MBTS Apartments on Lot 18 in Manchester-By-The-Sea, Massachusetts.

6.1 *Site Grades and Slopes*

Examination of the Site grading plans indicates that cuts into the unconsolidated soil formations and the bedrock will be required to achieve the design elevations (Figure 3):

- Cuts of approximately 25 to 30 feet into the bedrock will be needed within the proposed building footprint.

- Cuts into the Site soil formations appear to be approximately 25 to 45 feet at the access driveway near School Street.

- Fills of up to about 15 feet will be needed to reach the driveway subgrade elevation along the Site westerly side.

- Higher sidehill fills will be needed east and west of the proposed building footprint.

Slopes constructed from the on-site silty sand and gravel soils (or from imported borrow soils) could be designed as unreinforced soil slopes at maximum slope angles of 2H:1V (26º from the horizontal) when constructed of engineered fills properly placed and compacted under observation of a geotechnical engineer. Steeper slopes, up to 1½H:1V (34º from the horizontal), could be constructed as reinforced soil slopes. The sidehill fills will need to be keyed into the existing slope soil and bedrock formations during placement and compaction of each lift of material. All final slope surfaces must be protected from erosion using a rip rap facing or an erosion control matting system.

6.2 *Rock Slopes*

If the final design includes rock-cuts, the design geotechnical report should include an analysis of the stability of proposed rock cuts that will be higher than 15 feet. Rock cuts will require rockfall catchments along the bottoms of the rock cuts; the width of the catchments will be controlled by the height of the cuts and the strength and stability of the rock. Note that it appears that the current preliminary Site design does not require permanent rock cut slopes.

6.3 *Foundation Conditions*

Based on the Allen & Major Grading & Drainage Plan (Sheet C-103), it appears that all, or most, of the building footprint would be founded in bedrock that will have to be blasted to achieve the design grades (Figure 3). These subsurface conditions should be confirmed with test borings advanced during the final design geotechnical investigation. The test borings will be used to determine the bearing capacity for the building foundation design.

6.4 *Groundwater and Drainage Considerations*

We did not observe any indications of groundwater seeps or springs. We expect that groundwater will not be encountered during the general Site grading and earthwork. However, the deep cuts within the proposed building footprint could encounter groundwater within the bedrock. This could require installation of foundation drains, vapor barriers, and/or subslab drains below the parking garage slab. Observation wells should be installed within the bedrock during the design phase geotechnical investigation that will allow for periodic measurements of the groundwater elevations that will be encountered in the bedrock during construction.

Stormwater management could potentially be accomplished with open or underground basins that infiltrate water into the underlying silty sand and gravel formation. The depth to bedrock and the infiltration capacity of the silty sand and gravel soils will need to be determined during the Site design phase. The potential for groundwater mounding within the Site soils (below the infiltration systems) could be a requirement of the design and permitting of the stormwater management systems.

6.5 *Reuse of Site Materials*

A preliminary assessment of the suitability of using the unconsolidated soils and the bedrock at the Site in the proposed construction is based on the soil classifications and observations at the Site. The suitability of these materials is summarized below.

1. The topsoil is not suitable for reuse except in landscaping areas and should be stripped completely from the roadway and building footprint areas, as well as areas proposed for engineered fills.

2. The Fill Materials appeared to consist chiefly of boulders and blasted ledge blocks, with frequent fragments of concrete slabs, concrete blocks, asphalt pavements, and refuse. After culling the metals and refuse, the remaining materials could potentially be processed and blended with the blasted bedrock and the silty sand and gravel soils to produce a suitable material for reuse in the engineered fills on-site.

3. The naturally occurring silty sand and gravel soils would likely be suitable for reuse as engineered fill materials with minimal processing. These soils do contain a significant number of large boulders that could be crushed and blended into the silty sand and gravel for reuse as raise-in-grade fills.

4. The granite bedrock could potentially be crushed and processed into a number of materials for reuse in the proposed construction (for example, engineered fills, crushed stone products, or riprap for slope facings). Samples of the rock should be tested for durability (using the Los Angeles Abrasion test method).

We appreciate the opportunity to provide these geotechnical engineering services to you and the MBTS project. If you have any questions or require additional information, please contact us at (603) 668-6016 or at kmilender@millerengandtesting.com.

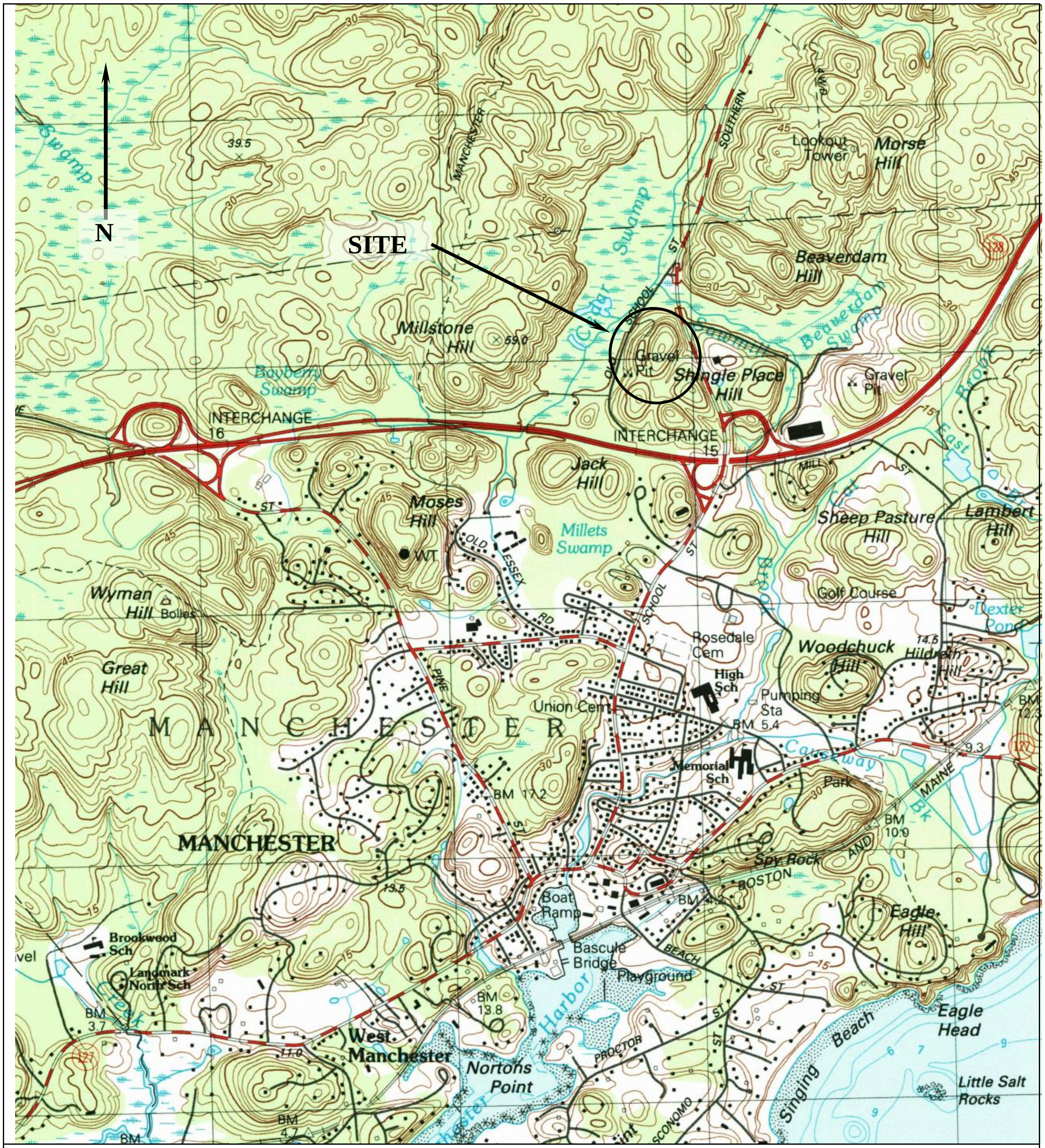
Very truly yours,
MILLER ENGINEERING & TESTING, INC.

COMMONWEALTH OF MASSACHUSETTS
KENNETH W. MILENDER
CIVIL
No. 50021
REGISTERED
PROFESSIONAL ENGINEER

for

Kenneth W. Milender, P.G., P.E.	Frank K. Miller, P.E.
Senior Geotechnical Engineer	Executive Vice President

Attachments

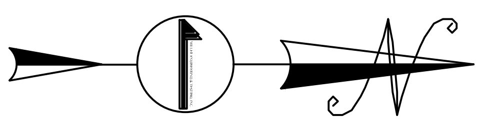


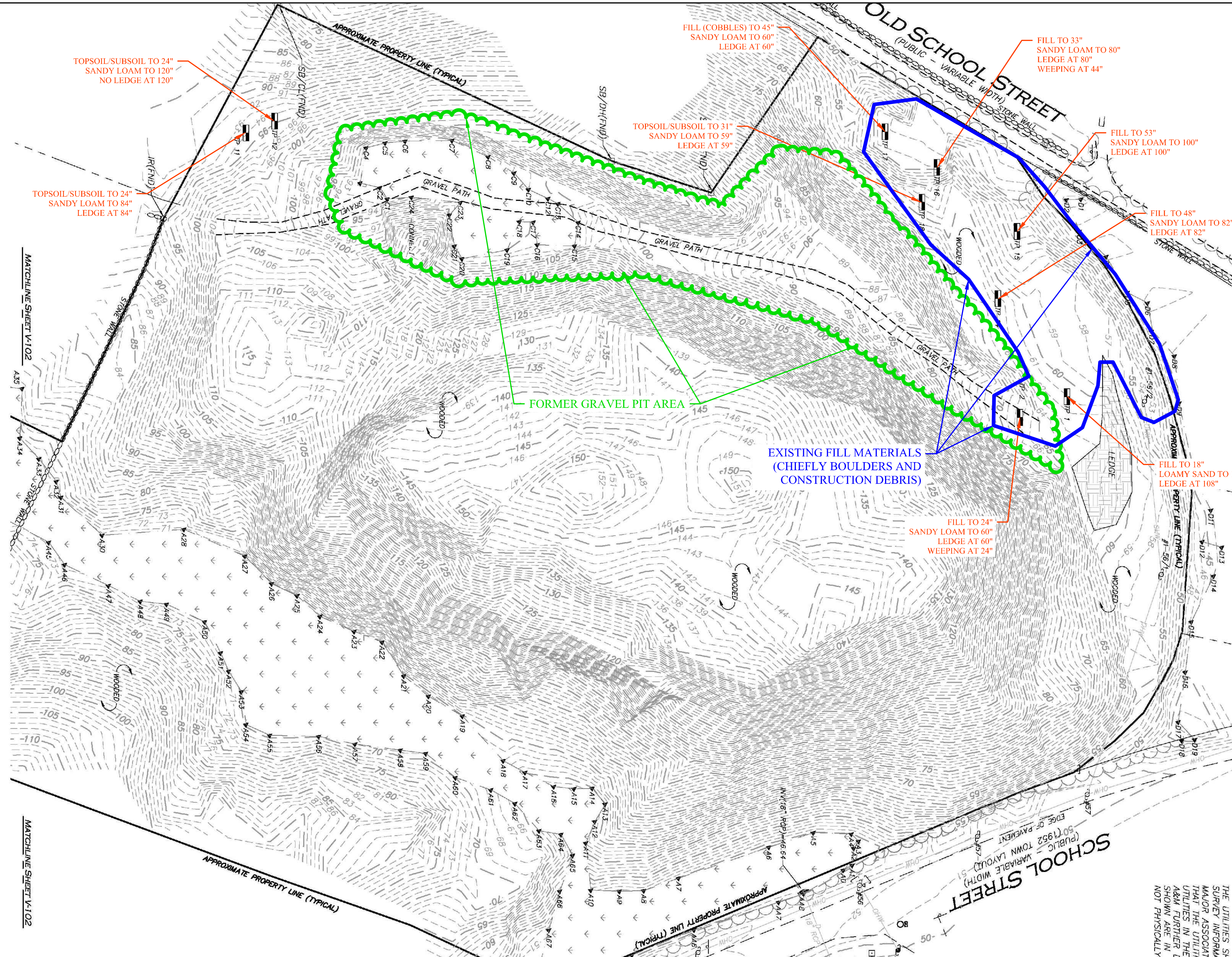
Source: A portion of the U.S.G.S. Salem, MA 7½- x15-minute topographic quadrangle map (1985).

GEOTECHNICAL RECONNAISSANCE	SITE LOCATION MAP
Proposed MBTS Apartments School Street Manchester-By-The-Sea, MA July, 2020 Miller Project No. 20.119.NH	FIGURE 1

NOTES

1. This plan is a reproduction of portions of "Existing Conditions Plan, Manchester, MA", (dated April 15, 2020) by Allen & Major Associates, Inc. of Woburn, MA.
2. Fill boundaries are based on our visual observation and Allen & Major's Test Pits.





GRAPHIC SCALE

100 0 50 100 200

(IN FEET)

MILLER ENGINEERING & TESTING, INC.

100 SHEFFIELD ROAD - PO BOX 4776
MANCHESTER, NEW HAMPSHIRE 03108
TEL (603) 668-6016 // FAX (603) 668-8641

MBTS Apartments
Manchester, MA
July 2020
Project No. 20.119.NH

EXISTING CONDITIONS AND TEST PIT LOCATIONS

FIGURE No. 2

NOTES

1. This plan is a reproduction of portions of "Grading & Drainage Plan, Manchester, MA", (not dated) by Allen & Major Associates, Inc. of Woburn, MA.

GRAPHIC SCALE

80 0 40 80 160

(IN FEET)

MILLER ENGINEERING & TESTING, INC.

100 SHEFFIELD ROAD - PO BOX 4776
MANCHESTER, NEW HAMPSHIRE 03108
TEL (603) 668-6016 // FAX (603) 668-8641

MBTS Apartments
Manchester, MA
July 2020
Project No. 20.119.NH

PROPOSED SITE LAYOUT

FIGURE No. 3

ATTACHMENT A

Limitations

LIMITATIONS

Explorations

1. The analyses, recommendations and designs submitted in this report are based in part upon the data obtained from subsurface explorations. The nature and extent of variations between these explorations may not become evident until construction. If variations then appear evident, it will be necessary to re-evaluate the recommendations of this report.

2. The generalized soil profile described in the text is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretation of widely spaced explorations and samples; actual soil transitions are probably more gradual. For specific information, refer to the boring logs.

3. Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. These data have been reviewed and interpretations have been made in the text of this report. However, it must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors differing from the time measurements were made.

Review

4. It is recommended that this firm be retained to review final design plans and specifications. In the event that any changes in the nature, design, or location of the structures are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of the report modified or verified in writing by Miller Engineering & Testing, Inc.

Construction

5. It is recommended that this firm be retained to provide soils engineering services during the excavations and foundation construction phases of the work. This is to observe compliance with the design concepts, specifications, or recommendations and to allow design changes in the event that subsurface conditions differ from those anticipated prior to the start of construction.

Use of Report

6. This report has been prepared for the exclusive use of **SLV SCHOOL STREET, LLC** for the proposed **MBTS Apartments** at **School Street** in **Manchester-By-The-Sea, Massachusetts** in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made.

7. This soil and foundation engineering report has been prepared for this project by Miller Engineering & Testing, Inc. This report was completed for design purposes and may be limited in its scope to prepare an accurate bid. Contractors wishing a copy of the report may secure it with the understanding that its scope is limited to design considerations only.

ATTACHMENT B

Historical Maps and Aerial Photographs

MBTS Apartments

School Street

Manchester, MA 01944

Inquiry Number: 6120693.1

July 14, 2020

The EDR Aerial Photo Decade Package

EDR®

6 Armstrong Road, 4th floor
Shelton, CT 06484
Toll Free: 800.352.0050
www.edrnet.com

EDR Aerial Photo Decade Package

07/14/20

Site Name:

MBTS Apartments
School Street
Manchester, MA 01944
EDR Inquiry # 6120693.1

Client Name:

Miller Engineering, Inc.
100 Sheffield Road
Manchester, NH 03108
Contact: Ken Milender

Environmental Data Resources, Inc. (EDR) Aerial Photo Decade Package is a screening tool designed to assist environmental professionals in evaluating potential liability on a target property resulting from past activities. EDR's professional researchers provide digitally reproduced historical aerial photographs, and when available, provide one photo per decade.

Search Results:

Year	Scale	Details	Source
2016	1"=500'	Flight Year: 2016	USDA/NAIP
2012	1"=500'	Flight Year: 2012	USDA/NAIP
2008	1"=500'	Flight Year: 2008	USDA/NAIP
1995	1"=500'	Acquisition Date: March 29, 1995	USGS/DOQQ
1986	1"=500'	Flight Date: April 01, 1986	USDA
1978	1"=500'	Flight Date: April 23, 1978	USGS
1969	1"=500'	Flight Date: April 09, 1969	USGS
1960	1"=500'	Flight Date: May 19, 1960	USGS
1952	1"=500'	Flight Date: August 26, 1952	USDA
1938	1"=500'	Flight Date: November 10, 1938	USGS

When delivered electronically by EDR, the aerial photo images included with this report are for ONE TIME USE ONLY. Further reproduction of these aerial photo images is prohibited without permission from EDR. For more information contact your EDR Account Executive.

INQUIRY #: 6120693.1

YEAR: 2016

= 500'

N

EDR

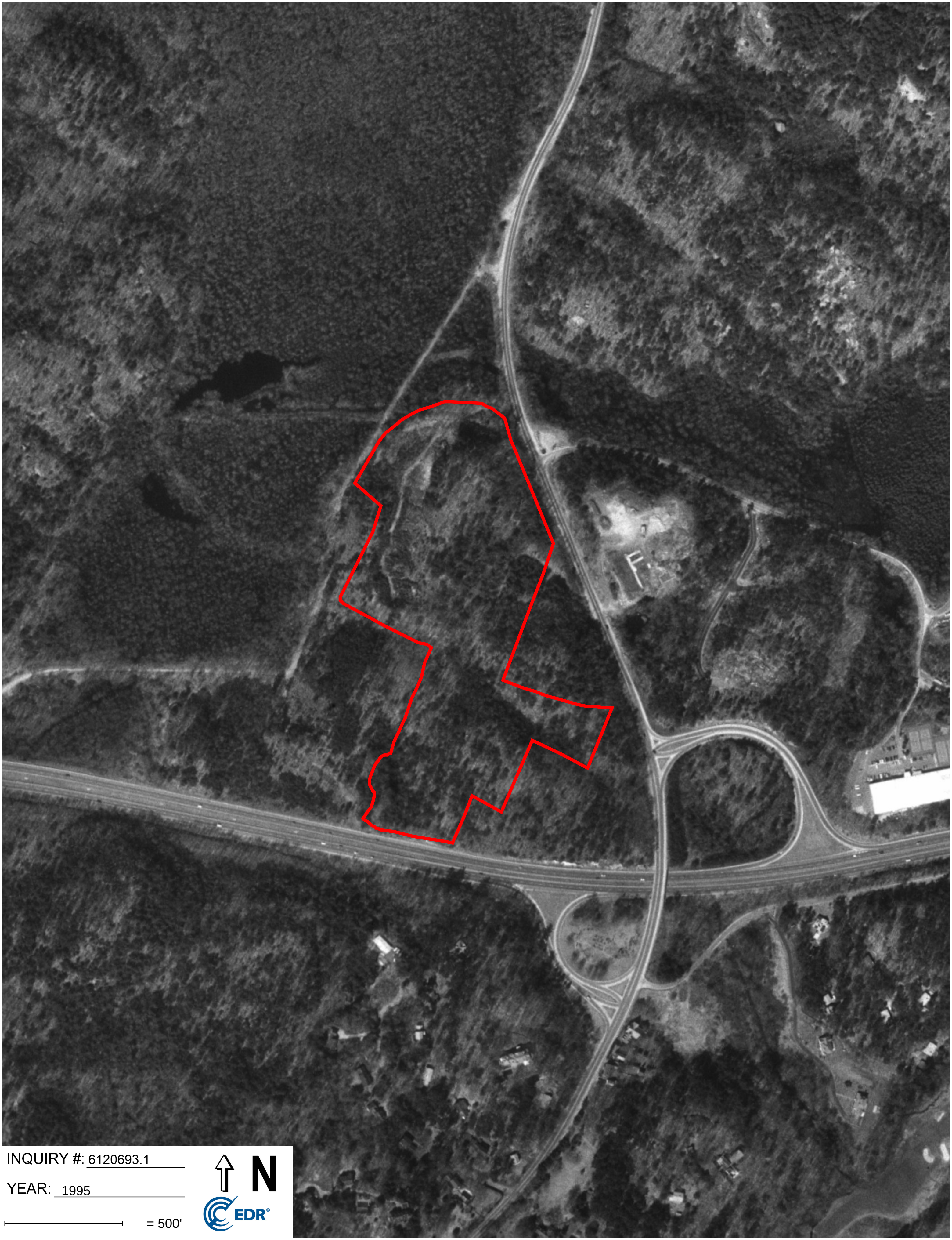

INQUIRY #: 6120693.1
YEAR: 2012
= 500'
N
EDR

INQUIRY #: 6120693.1

YEAR: 2008

= 500'

N



INQUIRY #: 6120693.1

YEAR: 1995

= 500'

N

EDR

INQUIRY #: 6120693.1

YEAR: 1986

= 500'

N

INQUIRY #: 6120693.1

YEAR: 1978

= 500'

N

INQUIRY #: 6120693.1

YEAR: 1969

= 500'

N

EDR

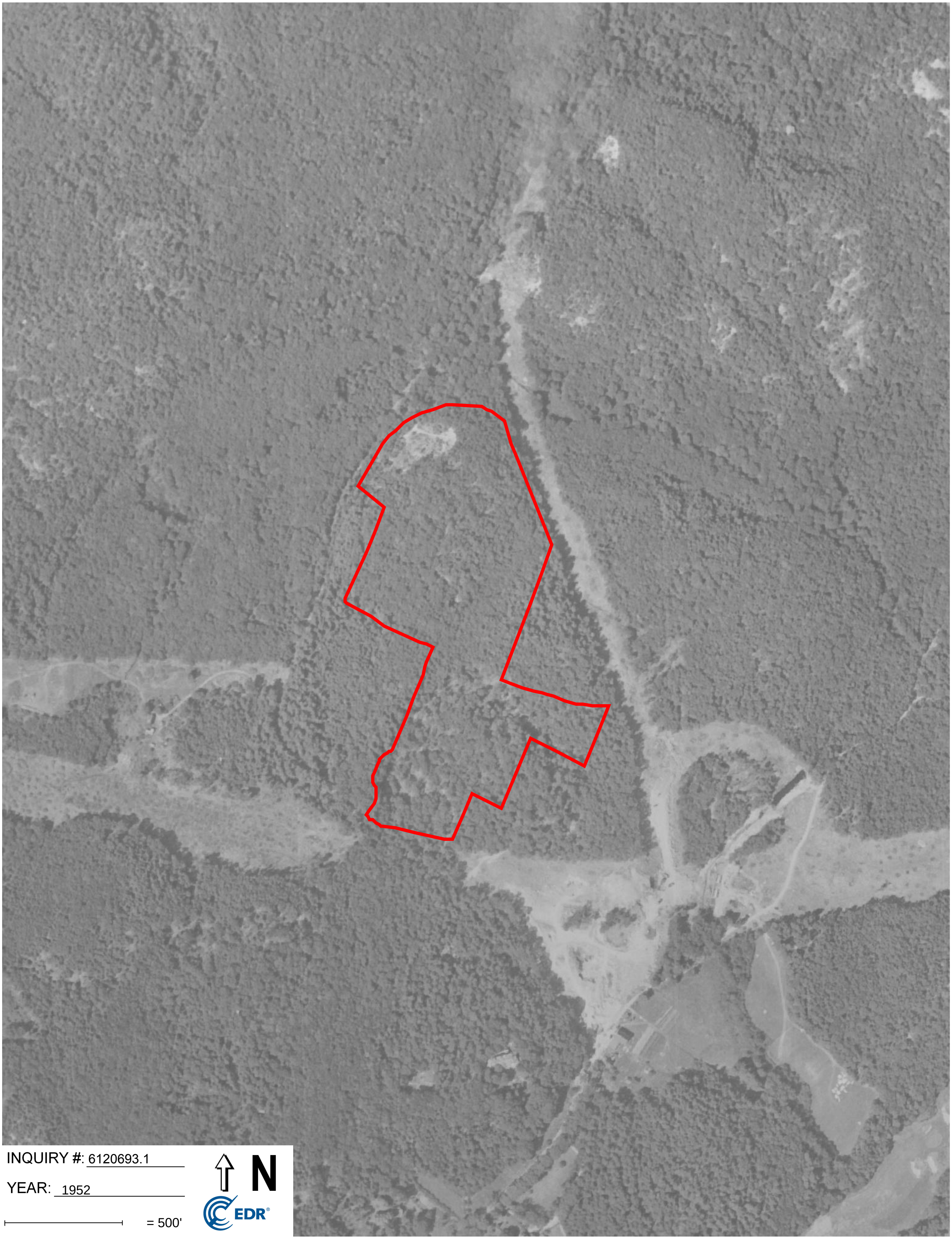
INQUIRY #: 6120693.1

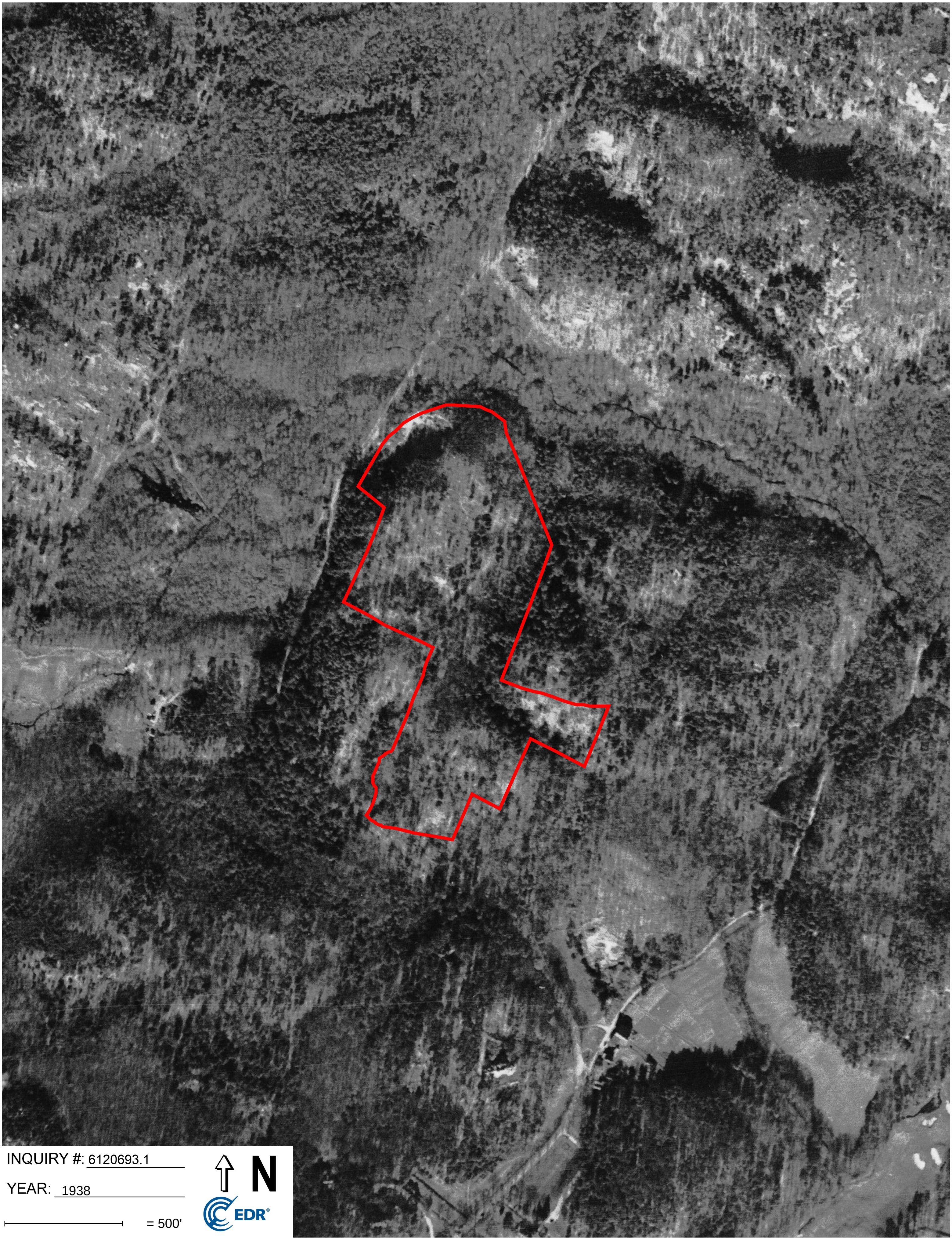
YEAR: 1960

= 500'

N

EDR


INQUIRY #: 6120693.1
YEAR: 1952
= 500'
N
EDR



INQUIRY #: 6120693.1

YEAR: 1938

= 500'

N

EDR

U.S. GEOLOGICAL SURVEY
J.W. POWELL,
DIRECTOR.

MASSACHUSETTS
SALEM SHEET

STATE OF MASSACHUSETTS
FRANCIS A. WALKER
HENRY L. WHITING } COMMISSIONERS
N.S. SHALER

Henry Gannett, Chief Geographer.
Marcus Baker, Geographer in charge.
Triangulation by the U.S. Coast and Geodetic and Borden Surveys.
Coast line by the U.S. Coast and Geodetic Survey.
Topography by E.W. Natter.
Surveyed in 1886.

Scale 62,500
Miles

Contour Interval 20 feet.
Datum is mean Sea level.

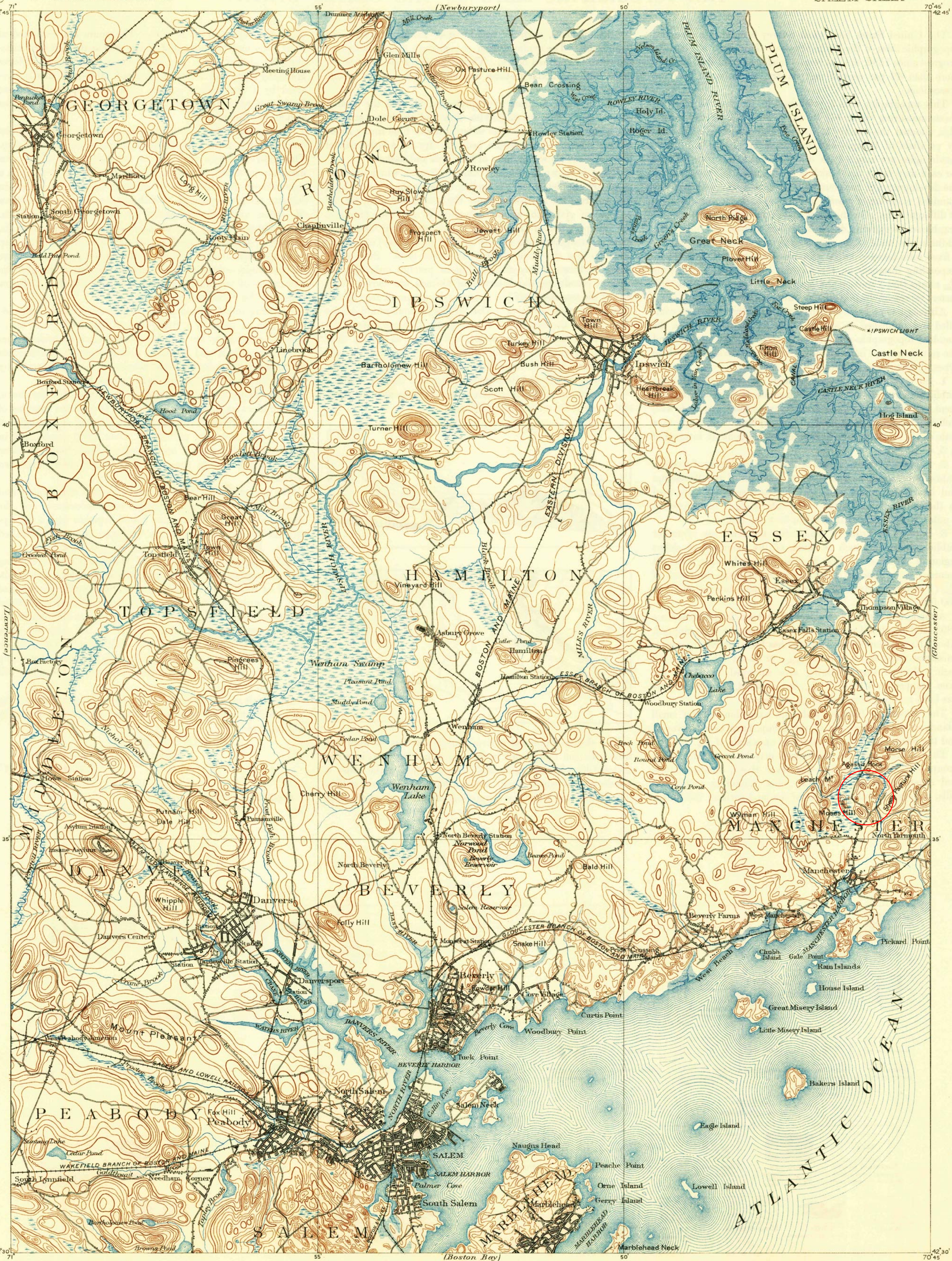
Edition of Oct. 1888.

250

Salem Ma

DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

MASSACHUSETTS
SALEM SHEET



Henry Gannett, Chief Geographer.
Marcus Baker, Geographer in charge.
Triangulation by the U.S. Coast and Geodetic and Borden Surveys.
Coast line by the U.S. Coast and Geodetic Survey.
Topography by E.W.F. Natter.
Surveyed in 1886.

SURVEYED IN COOPERATION WITH THE STATE OF MASSACHUSETTS.

Scale $\frac{1}{62500}$

Contour Interval 20 feet
Datum is mean Sea level.

Edition of Oct. 1893, reprinted 1936
Polyconic projection

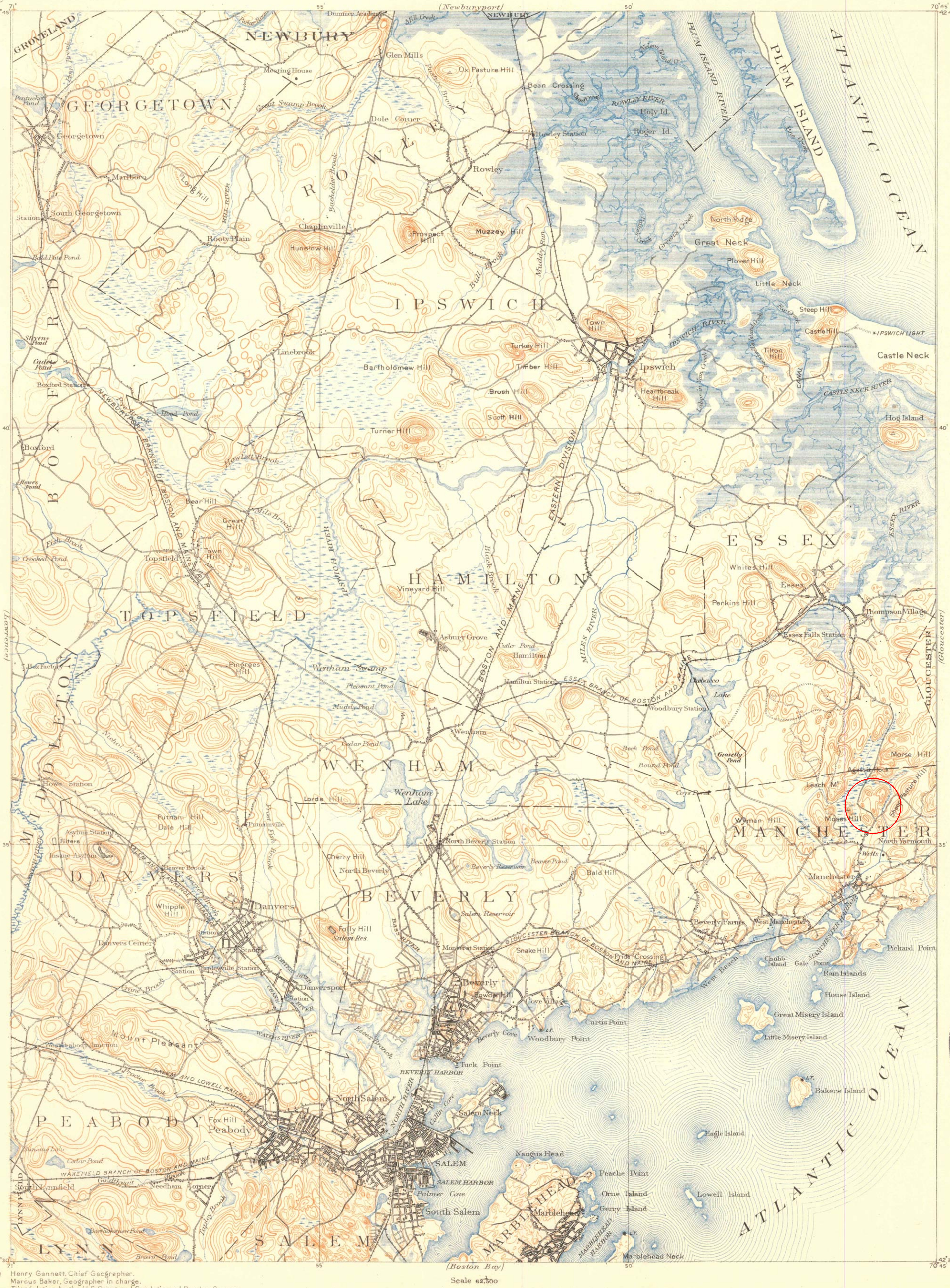
This map made from surveys without spirit level control.

SALEM, MASS.

U.S. GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

PARTIAL REVISION BY MASSACHUSETTS
COMMISSION ON WATERWAYS AND PUBLIC LANDS 1917

MASSACHUSETTS
SALEM SHEET



Henry Gannett, Chief Geographer.
Marcus Baker, Geographer in charge.
Triangulation by the U.S. Coast and Geodetic and Borden Surveys.
Coast line by the U.S. Coast and Geodetic Survey.
Topography by E.W.F. Natter.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour Interval 20 feet.
Datum is mean sea level.

SALEM, MASS.

37

CORPS OF ENGINEERS, U. S. ARMY
PROGRESSIVE MILITARY MAP

FINAL SHEET
891-N-III-W/2

MASSACHUSETTS
SALEM QUADRANGLE

Field work and compilation under the direction of Col. W. M. Black, Corps of Engineers, U. S. A. Department Engineer, Eastern Department. Nov. 1915

Field work under the immediate supervision of Capt. V. L. Peterson, Corps of Engineers, U. S. A.

Base map from U. S. G. S. engravings. Corrections and additions by Department Engineer, Eastern Department.

Soundings expressed in feet and referred to mean low water, are from U. S. C. & G. S. Charts. Nos. 108 & 109.

Scale $\frac{1}{62500}$

Contour Interval 20 feet

Datum is mean sea level

NOTE: OFFICERS USING THIS MAP WILL MARK HEREON CORRECTIONS AND ADDITIONS WHICH COME TO THEIR ATTENTION AND MAIL DIRECT TO "THE CHIEF OF ENGINEERS, WASHINGTON, D.C."

Central Map Reproduction Plant, Engineer School, Washington Barracks, D.C. 1919

APPROXIMATE MEAN DECLINATION 1918

Salem, Mass.
November, 1919

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

UNITED STATES
DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

MASSACHUSETTS
(ESSEX COUNTY)
MARBLEHEAD NORTH QUADRANGLE
7.5 MINUTE SERIES

Topography by J.L.Farmer, B.H.Minnich, and L.D.Olsen
Surveyed in 1942. Revised in 1950
Boundaries in tidewater areas from information furnished by Massachusetts Department of Public Works
Red tint indicates areas in which only landmark buildings are shown

APPROXIMATE MEAN DECLINATION, 1942

Scale 1:31680

Contour interval 10 feet
Datum is mean sea level

Polyconic projection. 1927 North American datum
5000 yard grid based on U.S. zone system, A
10000 foot grid based on Massachusetts (Mainland) rectangular coordinate system

ROAD CLASSIFICATION

HARD-SURFACE ALL WEATHER ROADS — DRY WEATHER ROADS
Heavy-duty — 4 LANE/6 LANE — Improved dirt
Medium-duty — 4 LANE/6 LANE — Unimproved dirt
Loose-surface, graded, or narrow hard-surface
U. S. Route — State Route

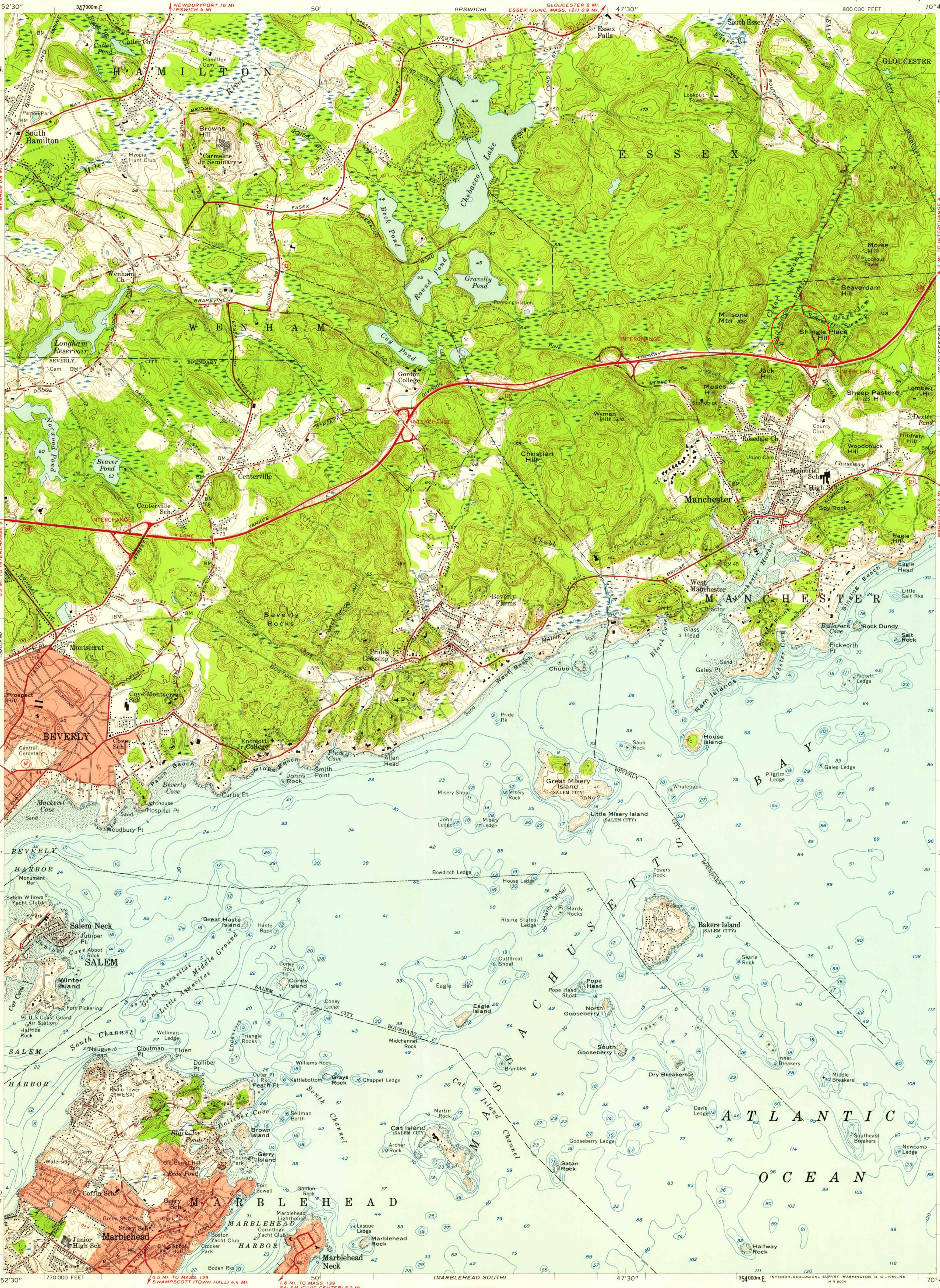
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

MARBLEHEAD NORTH, MASS.
Edition of 1945
reprinted 1951 with corrections
N4230-W7045/7.5

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS

MARBLEHEAD NORTH QUADRANGLE
MASSACHUSETTS–ESSEX CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



0.5 MI. TO MASS. 129
SWAMPSCOTT (TOWN HALL) 4.4 MI.

1.6 MI. TO MASS. 129
SALEM (CIVIC CENTER) 5.2 MI.

(MARBLEHEAD SOUTH)

INTERIOR–GEOLOGICAL SURVEY, WASHINGTON, D. C.–1959–NS
M R 5076

Mapped, edited, and published by the Geological Survey

Control by USC&GS, Massachusetts Harbor and Land Commission, and Massachusetts Geodetic Survey

Culture and drainage in part compiled from aerial photographs taken 1938. Topography by planetable surveys 1942. Culture revised by photogrammetric methods from aerial photographs taken 1955. Field check 1956

Hydrography compiled from USC&GS chart 240 (1956)

Polyconic projection. 1927 North American datum
10,000-foot grid based on Massachusetts (Mainland) coordinate system
1000-meter Universal Transverse Mercator grid ticks, zone 19, shown in blue

Red tint indicates areas in which only landmark buildings are shown

Boundaries in tidewater areas from information supplied by Massachusetts Department of Public Works

16°
MAGNETIC NORTH
TRUE NORTH
APPROXIMATE MEAN DECLINATION, 1956

SCALE 1:24 000

1 ½ 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 9 FEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

MASS.
QUADRANGLE LOCATION

ROAD CLASSIFICATION

Heavy-duty
Light-duty
Medium-duty
Unimproved dirt
State Route

MARBLEHEAD NORTH, MASS.
N4230—W7045/7.5

1956

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS

MARBLEHEAD NORTH QUADRANGLE
MASSACHUSETTS–ESSEX CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

Mapped, edited, and published by the Geological Survey

Control by USGS, USC&GS, and Massachusetts Geodetic Survey

Planimetry by photogrammetric methods from aerial photographs taken 1938. Topography by planetable surveys 1942. Revised from aerial photographs taken 1969. Field checked 1970

Selected hydrographic data compiled from USC&GS Charts 240 and 241 (1970). This information is not intended for navigational purposes

Polyconic projection. 1927 North American datum
10,000-foot grid based on Massachusetts coordinate system, mainland zone
1000-meter Universal Transverse Mercator grid ticks, zone 19, shown in blue

Boundaries in tidewater areas from information supplied by Massachusetts Department of Public Works

Red tint indicates areas in which only landmark buildings are shown

UTM GRID AND 1970 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
DEPTH CURVES AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 9.1 FEET

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1972

ROAD CLASSIFICATION

Primary highway, hard surface — Light-duty road, hard or improved surface
Secondary highway, hard surface — Unimproved road
Interstate Route — U. S. Route — State Route

QUADRANGLE LOCATION

MARBLEHEAD NORTH, MASS.
N4230—W7045/7.5

1970

AMS 6869 III SE—SERIES V814

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS

MARBLEHEAD NORTH QUADRANGLE
MASSACHUSETTS
7.5 MINUTE SERIES ORTHOPHOTOQUAD

(GEORGETOWN) 6869 IV NW
6869 I NW (GLOUCESTER)
6869 III NE (IPSWICH)
6869 II SW (SALEM)
(GLOUCESTER) 6869 II NW
(LYNN) 6868 IV NW
(MARBLEHEAD SOUTH) 6868 IV NE

Produced and published by the Geological Survey

Orthophotograph prepared from 1:80,000-scale aerial photograph taken April 1, 1977

Projection and 10,000-foot grid ticks: Massachusetts coordinate system, mainland zone (Lambert conformal conic) 1000-meter Universal Transverse Mercator grid, zone 19. 1927 North American datum

Photoimagery rectified by optical scanning which may produce double or mismatched images; use the mean of image positions for map point

MN GN
15½° 276 MILS
1°14′ 22 MILS

UTM GRID AND 1977 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:25 000

1 0 1 2 KILOMETERS
0.5 0 1 MILES
1000 0 1000 2000 3000 4000 5000 FEET

PRINCIPAL NUMBERED HIGHWAYS

Interstate Route U. S. Route State Route

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, RESTON, VIRGINIA 22092

MASS.
QUADRANGLE LOCATION

42070-E7-OQ-025

This quadrangle area also covered by
1:25,000-scale topographic map

MARBLEHEAD NORTH, MASS.
N4230–W7045/7.5

1977

DMA 6869 III SE–SERIES V014

SALEM, MASSACHUSETTS ESSEX COUNTY

7.5 X 15 MINUTE SERIES (TOPOGRAPHIC)

42070-E7-TM-025

Salem
MASSACHUSETTS

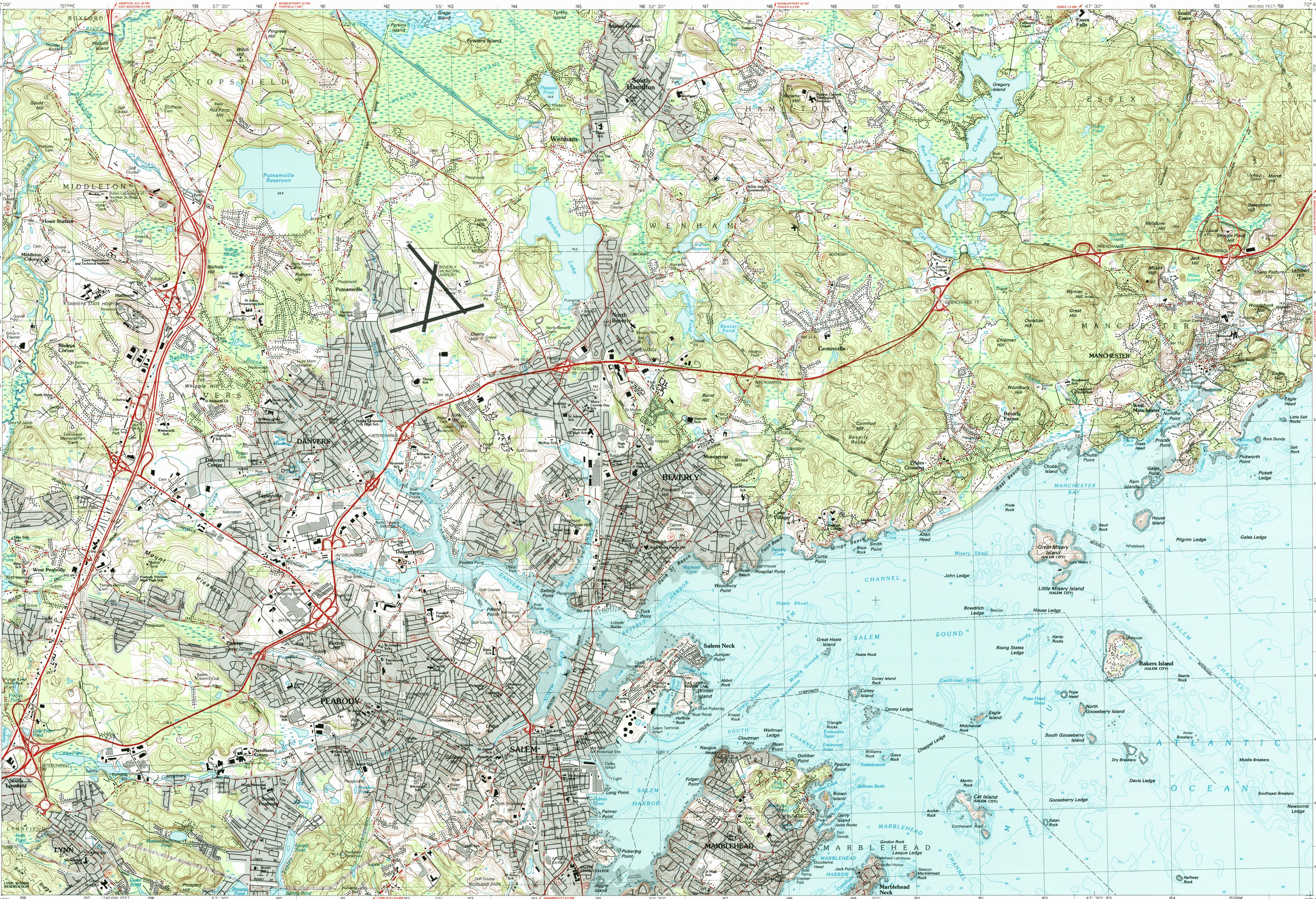
1:25 000-scale *metric* topographic map

7.5 X 15 MINUTE QUADRANGLE SHOWING

- Contours and elevations in meters
- Highways, roads and other manmade structures
- Water features
- Woodland areas
- Geographic names

GEOLOGICAL SURVEY

1985



Produced by the United States Geological Survey in cooperation with Massachusetts Department of Public Works

Control by USGS, NOS/NOAA, and Commonwealth of Massachusetts agencies

Compiled by photogrammetric methods from aerial photographs taken 1978. Field checked 1979. Map edited 1985

Supersedes Salem and Marblehead North 1:25,000-scale maps dated 1970

Selected hydrographic data compiled from NOS charts 13275 and 13276 (1981). This information is not intended for navigational purposes

Projection and 1000-meter grid: Universal Transverse Mercator, zone 19
10,000-foot grid ticks based on Massachusetts coordinate system, mainland zone
1927 North American Datum
To place on the predicted North American Datum 1983 move the projection lines 6 meters south and 42 meters west as shown by dashed corner ticks

There may be private inholdings within the boundaries of the National or State reservations shown on this map

CONTOUR INTERVAL 3 METERS
NATIONAL GEODETIC VERTICAL DATUM OF 1929
CONTROL ELEVATIONS SHOWN TO THE NEAREST 0.1 METER
OTHER ELEVATIONS SHOWN TO THE NEAREST 0.5 METER
DEPTH CURVES AND SOUNDINGS IN METERS
DATUM IS MEAN LOW WATER
THE RELATIONSHIP BETWEEN THE TWO DATUMS IS VARIABLE
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 2.7 METERS

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS

CONVERSION TABLE

Meters	Feet
1	3.2808
2	6.5617
3	9.8425
4	13.1234
5	16.4042
6	19.6850
7	22.9659
8	26.2467
9	29.5276
10	32.8084

To convert meters to feet multiply by 3.2808

To convert feet to meters multiply by 0.3048

DECLINATION DIAGRAM

MN GN 16° 284 MILS 1°16′ 23 MILS

UTM grid convergence (GN) and 1985 magnetic declination (MN) at center of map. Diagram is approximate

ADJOINING MAPS

1 Lawrence
2 Ipswich
3 Rockport
4 Reading
5 Gloucester
6 Boston North
7 Lynn

ISBN 0-607-23445-8

Topographic Map Symbols

Primary highway, hard surface
Secondary highway, hard surface
Light-duty road, hard or improved surface
Unimproved road; trail
Route marker: Interstate; U.S.; State
Railroad: standard gage; narrow gage
Bridge; drawbridge
Footbridge; overpass; underpass
Built-up area: only selected landmark buildings shown
House; barn; church; school; large structure
Boundary:
National, with monument
State
County, parish
Civil township, precinct, district
Incorporated city, village, town
National or State reservation; small park
Land grant with monument; found section corner
U.S. public lands survey: range, township; section
Range, township; section line: location approximate
Fence or field line
Power transmission line; located tower
Dam; dam with lock
Cemetery; grave
Campground; picnic area; U.S. location monument
Windmill; water well; spring
Mine shaft; prospect; adit or cave
Control: horizontal station; vertical station; spot elevation
Contours: index; intermediate; supplementary; depression
Distorted surface: strip mine, lava; sand
Bathymetric contours: index; intermediate
Perennial lake and stream; intermittent lake and stream
Rapids, large and small; falls, large and small
Submerged marsh; marsh, swamp
Land subject to controlled inundation; woodland
Scrub; mangrove
Orchard; vineyard

SCALE 1:25 000
1 CENTIMETER ON THE MAP REPRESENTS 250 METERS ON THE GROUND
CONTOUR INTERVAL 3 METERS

SALEM, MASSACHUSETTS
42070-E7-TM-025
1985

A pamphlet describing topographic maps is available on request

FOR SALE BY U.S. GEOLOGICAL SURVEY
P.O. BOX 25286, DENVER, COLORADO 80225

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map
US Topo

MARBLEHEAD NORTH QUADRANGLE
MASSACHUSETTS - ESSEX COUNTY
7.5-MINUTE SERIES

Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid:Universal Transverse Mercator, Zone 19T

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery....NAIP, July 2016 - September 2016
Roads.... U.S. Census Bureau, 2016
Names....GNIS, 1974 - 2018
Hydrography....National Hydrography Dataset, 2005 - 2016
Contours....National Elevation Dataset, 2012
Boundaries....Multiple sources; see metadata file 2016 - 2017
Wetlands....FWS National Wetlands Inventory 1986 - 2011

MN GN
14°50´ 264 MILS
1°14´ 22 MILS

UTM GRID AND 2017 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000 - m Square ID
CH
Grid Zone Designation
19T

SCALE 1:24 000

KILOMETERS · METERS · MILES · FEET

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18

QUADRANGLE LOCATION

ADJOINING QUADRANGLES
1 Georgetown
2 Ipswich
3 Gloucester OE N
4 Salem
5 Gloucester
6 Lynn
7 Marblehead South

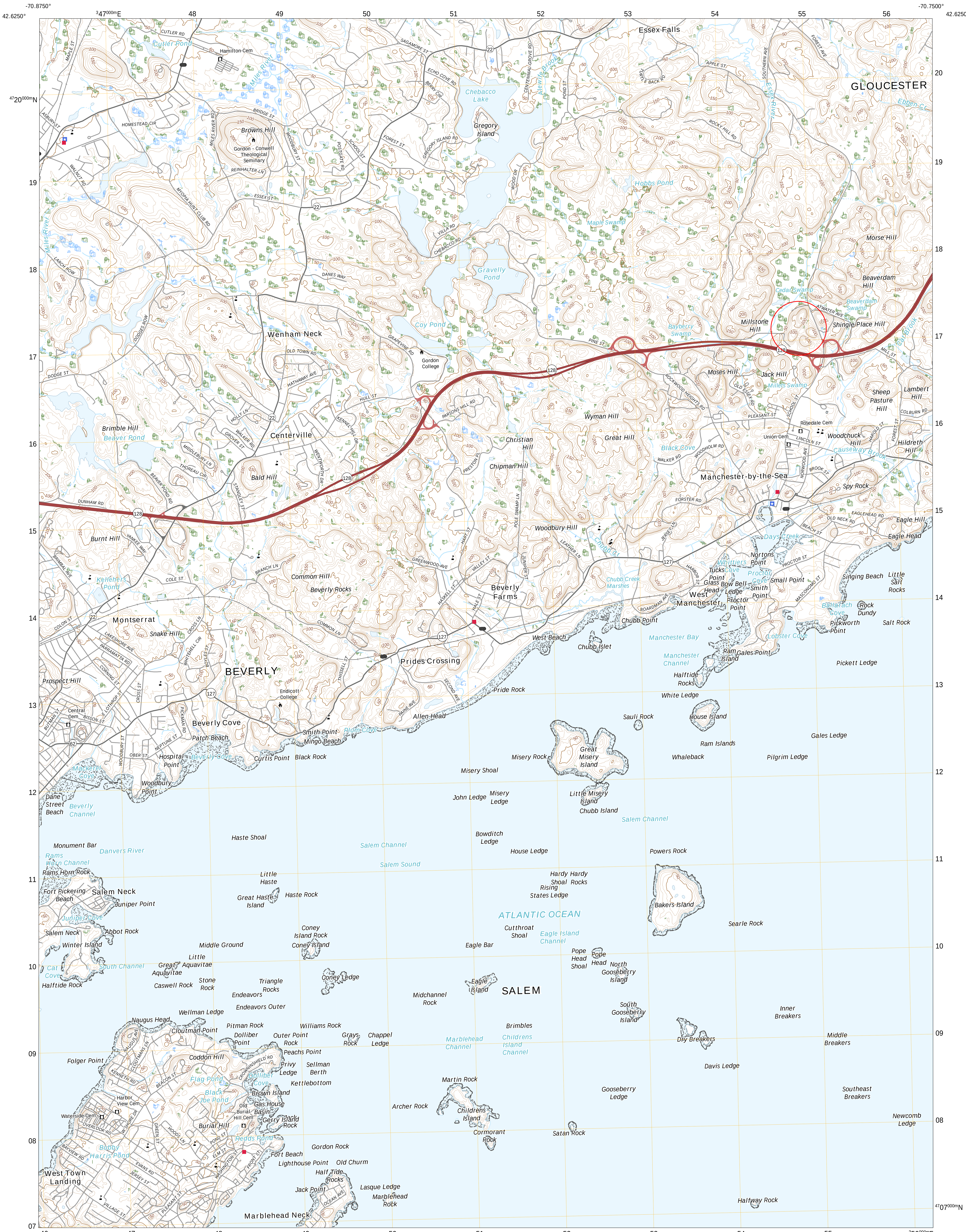
ROAD CLASSIFICATION
Expressway · Local Connector
Secondary Hwy · Local Road
Ramp · 4WD
Interstate Route · US Route · State Route

MARBLEHEAD NORTH, MA
2018

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

The National Map
US Topo

MARBLEHEAD NORTH QUADRANGLE
MASSACHUSETTS - ESSEX COUNTY
7.5-MINUTE SERIES



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and
1 000-meter grid: Universal Transverse Mercator, Zone 19T

This map is not a legal document. Boundaries may be generalized for this map scale. Private lands within government reservations may not be shown. Obtain permission before entering private lands.

Imagery........NAIP, July 2016 - September 2016
Roads........U.S. Census Bureau, 2016
Names........GNIS, 1974 - 2018
Hydrography........National Hydrography Dataset, 2005 - 2016
Contours........National Elevation Dataset, 2012
Boundaries........Multiple sources; see metadata file 2016 - 2017
Wetlands........FWS National Wetlands Inventory 1986 - 2011

MN
GN
14°50´
264 MILS
1°14´
22 MILS

UTM GRID AND 2017 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000 - m Square ID
CH
Grid Zone Designation
19T

SCALE 1:24 000

KILOMETERS
METERS
MILES
FEET

CONTOUR INTERVAL 10 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.18

MASSACHUSETTS
QUADRANGLE LOCATION

1	2	3
4		5
6	7	

ADJOINING QUADRANGLES

1 Georgetown
2 Ipswich
3 Gloucester OE N
4 Salem
5 Gloucester
6 Lynn
7 Marblehead South

ROAD CLASSIFICATION

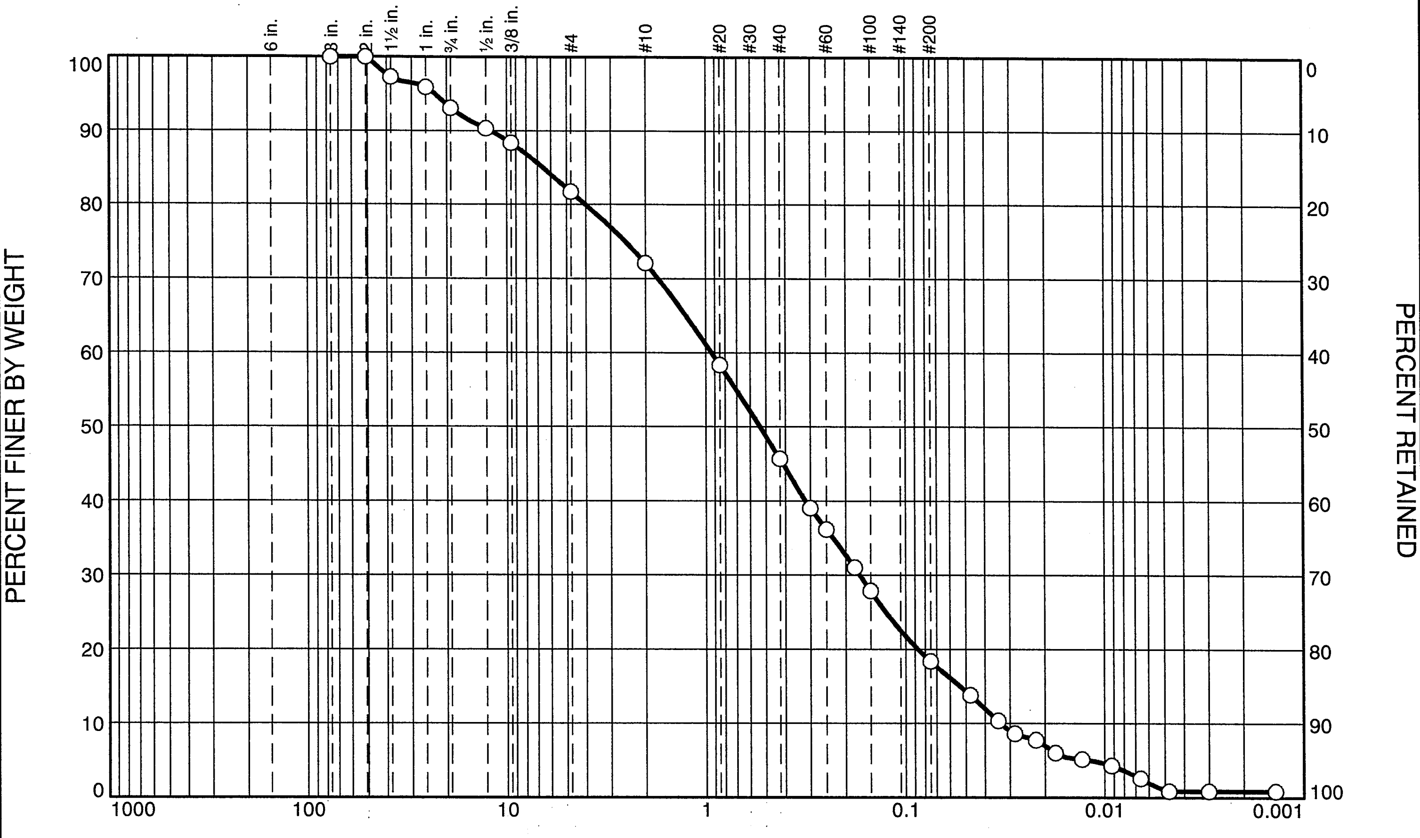
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

MARBLEHEAD NORTH, MA
2018

ATTACHMENT C

Laboratory Gradation Report

GRAINSIZE DISTRIBUTION REPORT



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	7	11	10	26	28	17	1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3"	100		
2"	100		
1.5"	97		
1"	96		
.75"	93		
.5"	90		
.375"	88		
#4	82		
#10	72		
#20	58		
#40	46		
#50	39		
#60	36		
#80	31		
#100	28		
#200	18		

* (no specification provided)

Material Description

SAND LITTLE GRAVEL.

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 11.9882 D_{85}= 6.5585 D_{60}= 0.9333
D_{50}= 0.5334 D_{30}= 0.1693 D_{15}= 0.0536
D_{10}= 0.0333 C_u= 28.00 C_c= 0.92

Classification

USCS= AASHTO=

Remarks

Source of Sample: N/A
Sample Number: L20238

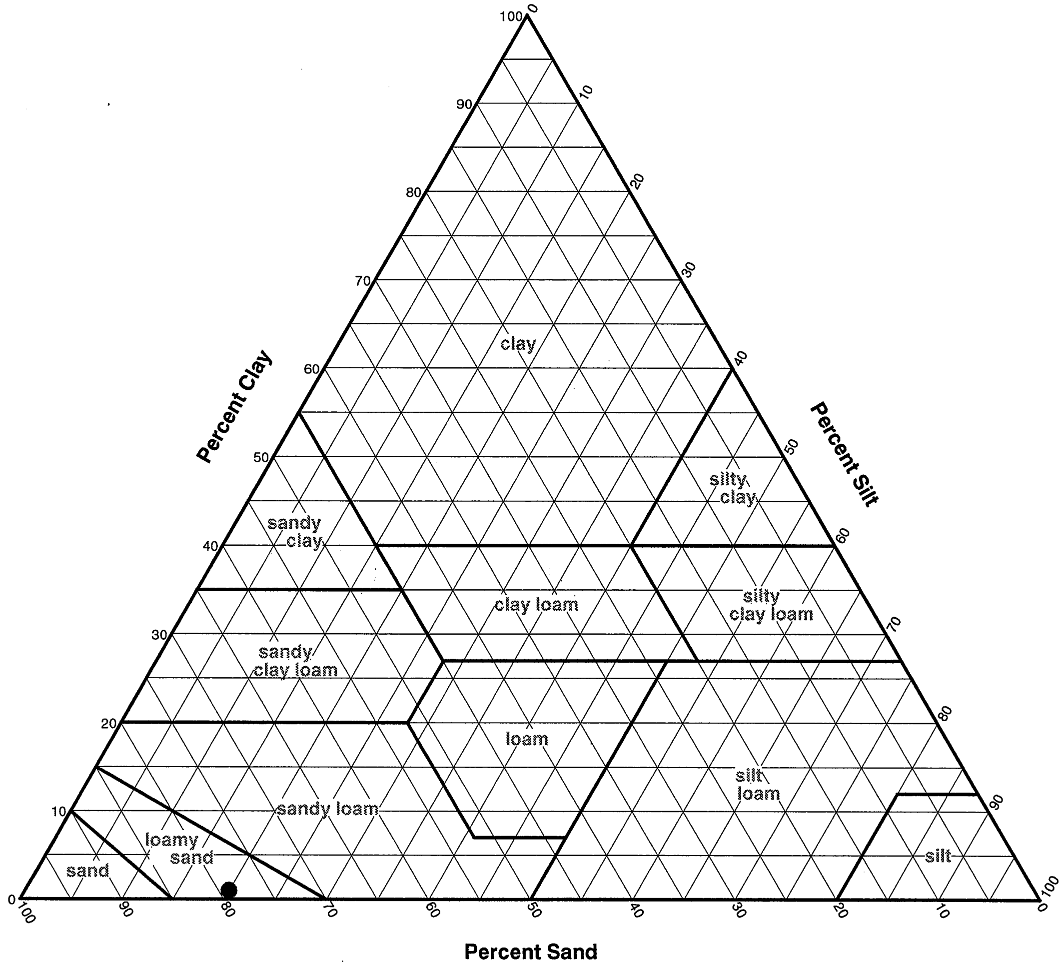
Date: 7-22-20

MILLER ENGINEERING & TESTING, INC.

Client:
Project: MBTS APARTMENTS
Project No: 20.119.NH **Figure** L20238

Tested By: DM/BM

USDA Soil Classification



SOIL DATA

	Source	Sample No.	Depth	Percentages From Material Passing a #10 Sieve: Sand	Silt	Clay	Classification
●	N/A	L20238		79	20	1	Loamy sand

MILLER ENGINEERING & TESTING, INC.

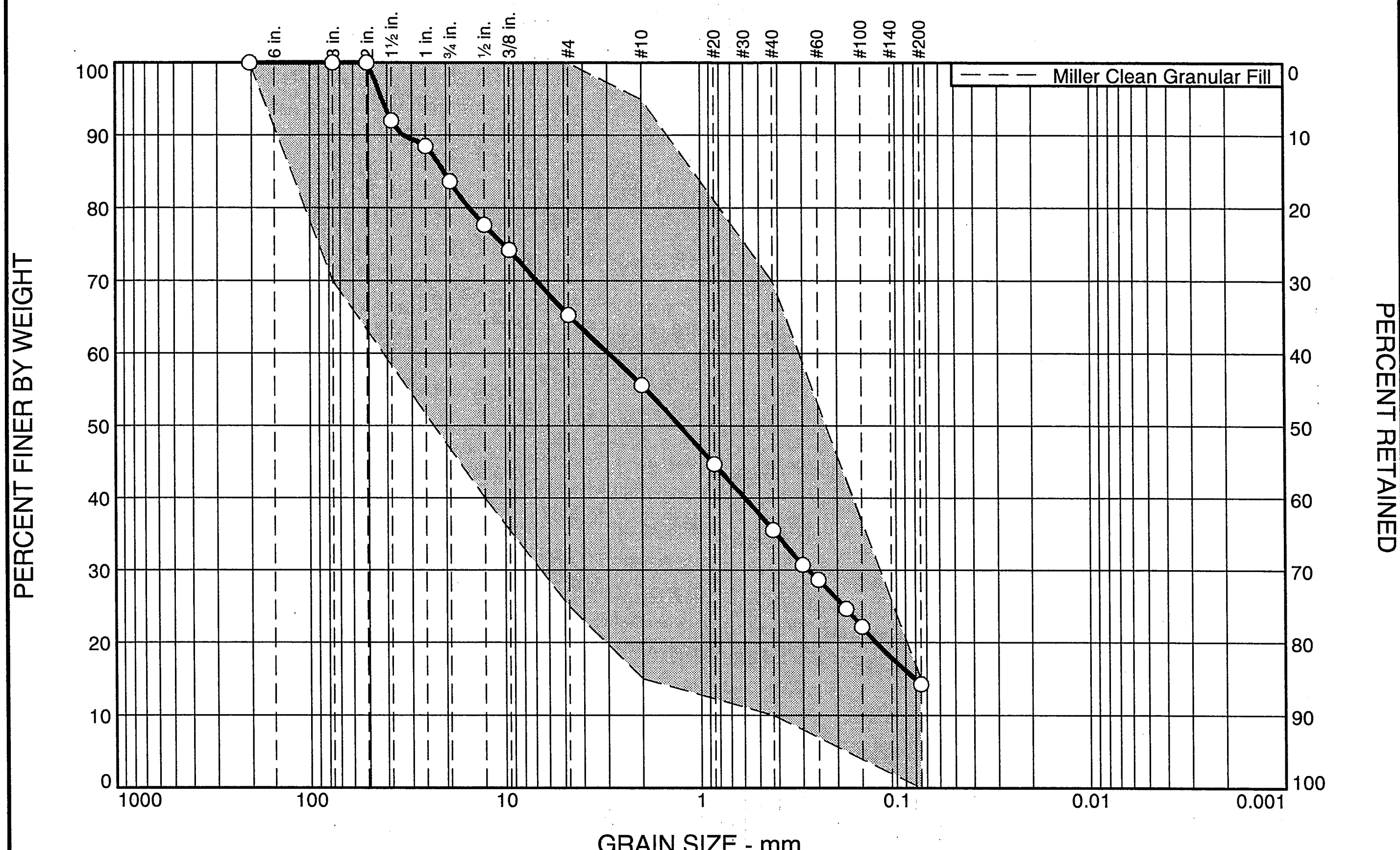
Client:

Project: MBTS APARTMENTS

Project No.: 20.119.NH

Figure L20238

GRAINSIZE DISTRIBUTION REPORT



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	16	19	9	20	22	14	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
8"	100	100	
3"	100	70 - 100	
2"	100		
1.5"	92		
1"	88		
.75"	84		
.5"	78	40 - 100	
.375"	74		
#4	65	25 - 100	
#10	56	15 - 95	
#20	45		
#40	36	10 - 70	
#50	31		
#60	29		
#80	25		
#100	22		
#200	14	0.0 - 15	

* Miller Clean Granular Fill

Material Description

SAMPLE # 1

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 32.8316 D_{85}= 20.4908 D_{60}= 2.9614
D_{50}= 1.2742 D_{30}= 0.2814 D_{15}= 0.0806
D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Source of Sample: N/A
Sample Number: L20232A

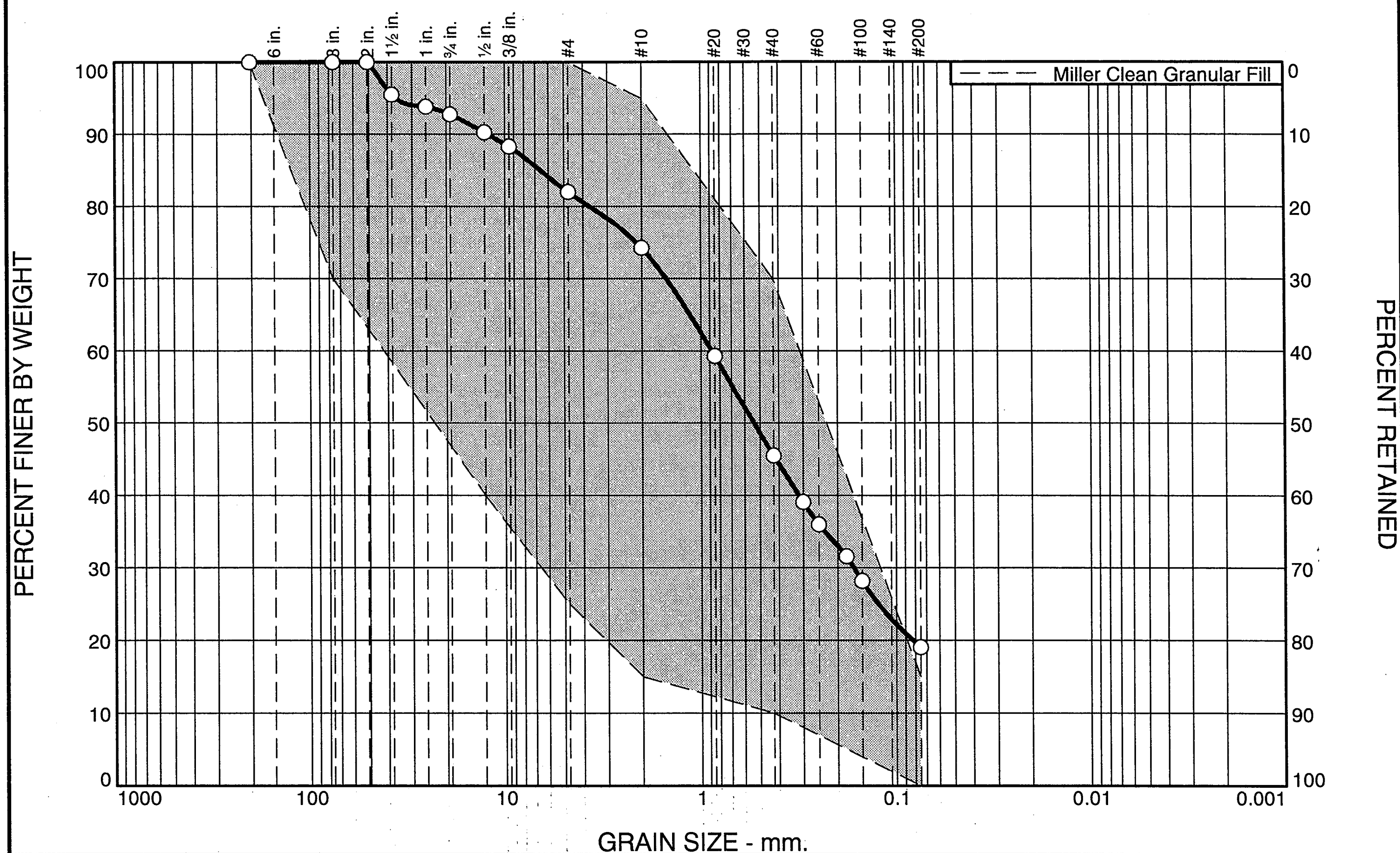
Date: 7-20-20

MILLER ENGINEERING & TESTING, INC.

Client:
Project: MBTS APARTMENTS
Project No: 20.119.NH
Figure L20232A

Tested By: DM/BM

GRAINSIZE DISTRIBUTION REPORT



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	7	11	8	28	27	19	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
8"	100	100	
3"	100	70 - 100	
2"	100		
1.5"	96		
1"	94		
.75"	93		
.5"	90	40 - 100	
.375"	88		
#4	82	25 - 100	
#10	74	15 - 95	
#20	59		
#40	46	10 - 70	
#50	39		
#60	36		
#80	32		
#100	28		
#200	19	0.0 - 15	X

* Miller Clean Granular Fill

Material Description

SAMPLE # 2

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 12.1689 D_{85}= 6.5538 D_{60}= 0.8797

D_{50}= 0.5356 D_{30}= 0.1648 D_{15}=

D_{10}= C_u= C_c=

Classification

USCS= AASHTO=

Remarks

Source of Sample: N/A
Sample Number: L20232B

Date: 7-20-20

MILLER ENGINEERING & TESTING, INC.

Client:
Project: MBTS APARTMENTS
Project No: 20.119.NH **Figure** L20232B

Tested By: DM/BM

Extreme Precipitation Tables

Northeast Regional Climate Center

Data represents point estimates calculated from partial duration series. All precipitation amounts are displayed in inches.

Smoothing	Yes
State	Massachusetts
Location	
Longitude	70.767 degrees West
Latitude	42.595 degrees North
Elevation	0 feet
Date/Time	Wed, 29 Jul 2020 13:03:32 -0400

Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.27	0.41	0.51	0.67	0.84	1.06	**1yr**	0.72	0.98	1.24	1.60	2.07	2.71	2.99	**1yr**	2.40	2.87	3.30	4.01	4.69	**1yr**
2yr	0.33	0.51	0.64	0.84	1.05	1.34	**2yr**	0.91	1.24	1.56	1.98	2.53	3.24	3.60	**2yr**	2.86	3.46	3.97	4.74	5.38	**2yr**
5yr	0.39	0.61	0.76	1.02	1.31	1.68	**5yr**	1.13	1.56	1.96	2.51	3.20	4.09	4.60	**5yr**	3.62	4.42	5.07	6.00	6.76	**5yr**
10yr	0.44	0.69	0.87	1.19	1.54	2.00	**10yr**	1.33	1.85	2.34	3.00	3.83	4.88	5.55	**10yr**	4.32	5.33	6.10	7.18	8.05	**10yr**
25yr	0.52	0.82	1.05	1.44	1.91	2.50	**25yr**	1.65	2.33	2.94	3.79	4.84	6.17	7.10	**25yr**	5.46	6.83	7.79	9.12	10.14	**25yr**
50yr	0.58	0.93	1.19	1.67	2.26	2.98	**50yr**	1.95	2.78	3.53	4.55	5.81	7.37	8.57	**50yr**	6.52	8.24	9.38	10.92	12.08	**50yr**
100yr	0.66	1.07	1.38	1.95	2.66	3.54	**100yr**	2.30	3.31	4.20	5.43	6.93	8.80	10.34	**100yr**	7.79	9.95	11.29	13.09	14.40	**100yr**
200yr	0.75	1.22	1.58	2.27	3.15	4.22	**200yr**	2.71	3.94	5.02	6.50	8.30	10.52	12.49	**200yr**	9.31	12.01	13.60	15.69	17.17	**200yr**
500yr	0.90	1.48	1.93	2.80	3.92	5.29	**500yr**	3.39	4.96	6.32	8.21	10.51	13.34	16.03	**500yr**	11.81	15.41	17.41	19.95	21.67	**500yr**

Lower Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.23	0.35	0.43	0.58	0.71	0.84	**1yr**	0.61	0.82	1.03	1.41	1.81	2.42	2.67	**1yr**	2.14	2.57	2.95	3.49	4.15	**1yr**
2yr	0.32	0.49	0.60	0.82	1.01	1.23	**2yr**	0.87	1.20	1.41	1.84	2.37	3.13	3.47	**2yr**	2.77	3.34	3.85	4.59	5.21	**2yr**
5yr	0.36	0.56	0.70	0.96	1.22	1.46	**5yr**	1.05	1.43	1.66	2.15	2.75	3.74	4.20	**5yr**	3.31	4.04	4.65	5.55	6.24	**5yr**
10yr	0.40	0.62	0.77	1.08	1.39	1.67	**10yr**	1.20	1.64	1.88	2.41	3.08	4.30	4.85	**10yr**	3.80	4.66	5.37	6.36	7.12	**10yr**
25yr	0.46	0.70	0.87	1.25	1.64	1.98	**25yr**	1.42	1.94	2.20	2.79	3.57	5.17	5.84	**25yr**	4.57	5.62	6.48	7.62	8.41	**25yr**
50yr	0.51	0.77	0.96	1.38	1.86	2.26	**50yr**	1.60	2.21	2.48	3.12	3.98	5.96	6.71	**50yr**	5.27	6.45	7.46	8.73	9.72	**50yr**
100yr	0.57	0.85	1.07	1.55	2.12	2.57	**100yr**	1.83	2.51	2.80	3.49	4.43	6.87	7.71	**100yr**	6.08	7.41	8.60	10.04	11.03	**100yr**
200yr	0.63	0.94	1.20	1.73	2.41	2.93	**200yr**	2.08	2.86	3.17	3.88	4.91	7.95	8.88	**200yr**	7.03	8.54	9.92	11.52	12.50	**200yr**
500yr	0.73	1.08	1.39	2.02	2.87	3.49	**500yr**	2.48	3.41	3.73	4.47	5.64	9.66	10.72	**500yr**	8.55	10.30	12.00	13.87	14.73	**500yr**

Upper Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.30	0.46	0.56	0.75	0.92	1.08	**1yr**	0.80	1.05	1.34	1.72	2.20	2.96	3.30	**1yr**	2.62	3.18	3.67	4.33	5.13	**1yr**
2yr	0.35	0.54	0.66	0.90	1.11	1.33	**2yr**	0.96	1.30	1.52	2.01	2.57	3.37	3.75	**2yr**	2.99	3.61	4.14	4.96	5.61	**2yr**
5yr	0.42	0.65	0.81	1.11	1.41	1.73	**5yr**	1.22	1.69	1.99	2.64	3.38	4.45	5.00	**5yr**	3.94	4.81	5.49	6.49	7.28	**5yr**
10yr	0.50	0.77	0.96	1.34	1.73	2.13	**10yr**	1.50	2.09	2.44	3.26	4.14	5.49	6.25	**10yr**	4.86	6.01	6.84	8.01	8.93	**10yr**
25yr	0.64	0.97	1.21	1.73	2.27	2.81	**25yr**	1.96	2.75	3.20	4.31	5.46	7.25	8.40	**25yr**	6.41	8.08	9.14	10.57	11.72	**25yr**
50yr	0.76	1.16	1.44	2.08	2.79	3.47	**50yr**	2.41	3.40	3.94	5.35	6.76	8.93	10.52	**50yr**	7.91	10.12	11.39	13.04	14.20	**50yr**
100yr	0.92	1.39	1.74	2.51	3.44	4.28	**100yr**	2.97	4.19	4.83	6.63	8.35	11.00	13.19	**100yr**	9.74	12.68	14.20	16.13	17.44	**100yr**
200yr	1.10	1.65	2.10	3.04	4.23	5.29	**200yr**	3.65	5.17	5.95	8.22	10.33	13.54	16.53	**200yr**	11.98	15.89	17.72	19.95	21.42	**200yr**
500yr	1.41	2.09	2.69	3.91	5.56	6.99	**500yr**	4.80	6.83	7.84	10.96	13.72	17.83	22.21	**500yr**	15.78	21.36	23.68	26.40	28.17	**500yr**

Powered by ACIS
Northeast Regional Climate Center

Manning's Roughness Coefficients ("n")

Conduit	Manning's Coefficients
Closed Conduits	
Asbestos-Cement Pipe	0.011 to 0.015
Brick	0.013 to 0.017
Cast Iron Pipe	
Cement-lined and seal-coated	0.011 to 0.015
Concrete (Monolithic)	
Smooth forms	0.012 to 0.014
Rough forms	0.015 to 0.017
Concrete Pipe	0.011 to 0.015
Corrugated-Metal Pipe (1/2 - STUL 34470 2 1/2-inch corrgtn.)	
Plain	0.022 to 0.026
Paved invert	0.018 to 0.022
Spun asphalt-lined	0.011 to 0.015
Plastic Pipe (Smooth)	0.011 to 0.015
Vitrified Clay	
Pipes	0.011 to 0.015
Liner channels	0.013 to 0.017
Open Channels	
Lined Channels	
Asphalt	0.013 to 0.017
Brick	0.012 to 0.018
Concrete	0.011 to 0.020
Rubble or riprap	0.020 to 0.035
Vegetal	0.030 to 0.040
Excavated or Dredged	
Earth, straight and uniform	0.020 to 0.030
Earth, winding, fairly uniform	0.025 to 0.040
Rock	0.030 to 0.045
Unmaintained	0.050 to 0.140
Natural Channels (minor streams, top width at flood state < 100 feet)	
Fairly regular section	0.030 to 0.070
Irregular section with pools	0.040 to 0.100

Source: Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers and the Water Pollution Control Federation, 1969.

Computation Sheet

Title	***MA DEP Standard Calculations***		By	DMR/SJL
Project	*School Street, Manchester-by-the-Sea, MA*		Chk'd	CMQ
Date	July 16, 2021		Apprv'd	CMQ
Revised	March 23, 2022			

RECHARGE & WATER QUALITY VOLUME CALCULATIONS

Rv = F * Impervious Area

Rv *= Required Recharge Volume, expressed in ft^3, cubic yards or acre-feet*

F *= Target Depth Factor associated with each Hydraulic Soil Group*

Impervious Area *= pavement & rooftop area on site*

V_{WQ} *= Required Water Quality Treatment Volume (ft^3)*

D_{WQ} *= Water Quality Depth (in)*

A_{IMP} *= Impervious Area (excluding non-metal roofs)*

					Recharge Required			Water Quality Volume Required	
			IMPERVIOUS AREA (S.F.) BY HSG						
W'SHED	Area (Sq. Ft)	Landscaped		HSG D (F=.1)	F Avg. (Inches)	Impervious Area (Sq. Ft)	Rv (ft^3)	D_{WQ} (Inch)	V_{WQ}
P-1	45,886	45,886		0	0.100	0	0	1.0	0
P-2	28,310	28,310		0	0.100	0	0	1.0	0
P-3	13,369	12,803		566	0.100	566	5	1.0	47
P-4	123,881	123,053		828	0.100	828	7	1.0	69
P-5	18,436	9,799		8,637	0.100	8,637	72	1.0	720
P-6	13,824	13,319		505	0.100	505	4	1.0	42
P-7	24,883	23,261		1,622	0.100	1,622	14	1.0	135
P-8	22,308	5,702		16,606	0.100	16,606	138	1.0	1,384
P-9	15,328	10,270		5,058	0.100	5,058	42	1.0	422
P-10	30,352	0		30,352	0.100	30,352	253	1.0	2,529
P-11	20,180	0		20,180	0.100	20,180	168	1.0	1,682
P-12	27,254	0		27,254	0.100	27,254	227	1.0	2,271
P-13	18,475	4,989		13,486	0.100	13,486	112	1.0	1,124
P-14	24,170	19,009		5,161	0.100	5,161	43	1.0	430
P-15	43,949	34,406		9,543	0.100	9,543	80	1.0	795
P-16	12,275	4,222		8,053	0.100	8,053	67	1.0	671
P-17	23,236	23,236		0	0.100	0	0	1.0	0
Total	**506,116**	358,265		147,851		10,536	**1,232**		**12,321**

STORMWATER RECHARGE SUMMARY CALCULATIONS

Rv = F * Impervious Area

Rv *= Required Recharge Volume, expressed in ft^3, cubic yards or acre-feet*

F *= Target Depth Factor associated with each Hydraulic Soil Group*

	Required (cf)	Provided (cf)	
Rv =	***984***	***10,350***	***BMP 1 - 96" CMP Underground Infiltration System (P-8, P-9, P-10, P-11, P-12, P-13, & P-14)***
Rv =	***160***	***2,041***	***BMP 2 - Bioretention Area/Rain Garden #1 (P-7, P-15, P-16 & P-17)***
Rv =	***76***	***826***	***BMP 3 - Bioretention Area/Rain Garden #2 (P-5, P-6) (NO RECHARGE CREDIT)***
Rv =	***12***	***0***	***Deminimus Unmitigated Area (P-1, P-2, P-3, P-4)***
Rv =	***1,232***	***12,391***	

Title	***MA DEP Standard Calculations***	By	DMR/SJL
Project	*School Street, Manchester-by-the-Sea, MA*	Chk'd	CMQ
Date	July 16, 2021	Apprv'd	CMQ
Revised	March 23, 2022		

STORMWATER QUALITY VOLUME CALCULATIONS

V_{WQ} *= Required Water Quality Treatment Volume, expressed in ft^3*

D_{WQ} *= Water Quality Depth*

A_{IMP} *= Impervious Area (pavement & rooftop area excluding non-metal roofs)*

	Required (cf)	Provided (cf)	
V_{WQ} =	*9,841*	*10,350*	***BMP 1 - 96" CMP Underground Infiltration System (P-8, P-9, P-10, P-11, P-12, P-13, & P-14)***
V_{WQ} =	*1,602*	*2,041*	***BMP 2 - Bioretention Area/Rain Garden #1 (P-7, P-15, P-16 & P-17)***
V_{WQ} =	*762*	*826*	***BMP 3 - Bioretention Area/Rain Garden #2 (P-5, P-6)***
V_{WQ} =	*116*	*0*	***Deminimus Unmitigated Area (P-1, P-2, P-3, P-4)***
V_{WQ} =	***12,321***	***13,217***	

DRAWDOWN CALCULATIONS (72 HOURS MAX)

$Time_{drawdown}$=(Rv) (1/Design Infiltration Rate in inches per hour) (Conversion for inches to feet) (1/bottom area in feet)

BMP 1 - Underground Infiltration System (Loamy Sand)	
Infiltration Rate (in/Hr)=	2.41
Bottom Area (ft^2) =	7,020
Infiltration Volume (ft^3) =	10,350
$Time_{drawdown}$ (Hours)=	7.34

BMP 2 - Bioretention Area/Rain Garden #1 (Loamy Sand)	
Infiltration Rate (in/Hr)=	2.41
Bottom Area (ft^2) =	5,704
Infiltration Volume (ft^3) =	2,041
$Time_{drawdown}$ (Hours)=	1.78

BMP 4 - Lined Bioretention Area/Rain Garden #2	
Infiltration Rate (in/Hr)=	2.41
Bottom Area (ft^2) =	4,318
Infiltration Volume (ft^3) =	826
$Time_{drawdown}$ (Hours)=	0.95

****BMP will not discharge to groundwater**

Computation Sheet

Title	***MA DEP Standard Calculations***	By	DMR/SJL
Project	*School Street, Manchester-by-the-Sea, MA*	Chk'd	CMQ
Date	July 16, 2021	Apprv'd	CMQ
Revised	March 23, 2022		

TSS REMOVAL CALCULATIONS WORKSHEET

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	Remaining Load (D-E)	B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	Remaining Load (D-E)
Deep Sump Catch Basins	0.25	1.00	0.25	0.75	Deep Sump Catch Basins	0.25	1.00	0.25	0.75
Proprietary Hydro-dynamic Device	0.50	0.75	0.38	0.38	Sediment Removal Proprietary Device	0.50	0.75	0.38	0.38
Surface Infiltration System w/ Outlet Control	0.80	0.38	0.30	0.08	Rain Garden	0.80	0.75	0.60	0.15
Bio-retention/ Rain Garden	0.80	0.08	0.06	0.02	N/A				
		Total TSS Removal =	99%				Total TSS Removal =	85%	

Computation Sheet

Title	***MA DEP Standard Calculations***	By	DMR/SJL
Project	*School Street, Manchester-by-the-Sea, MA*	Chk'd	CMQ
Date	July 16, 2021	Apprv'd	CMQ
Revised	March 23, 2022		

STORMWATER QUALITY FLOW RATE CALCULATIONS FOR WATER QUALITY UNITS

Structure Name	Total Area (Acres)	Imp. Area (Acres)	A^{IMP} (Sq. Miles)	Tc (min.)	Tc (hrs.)	WQV (inches)	qu (csm/in)
WQU-1	0.42	0.20	0.00031	6.0	0.10	1	774
WQU-2	0.28	0.18	0.00029	6.0	0.10	1	774
WQU-3	0.85	0.18	0.00028	6.0	0.10	1	774
WQU-4	0.72	0.16	0.00025	6.0	0.22	1	774
WQU-5	0.42	0.31	0.00048	6.0	0.10	1	774
WQU-6	0.51	0.38	0.00060	6.0	0.10	1	774

Water Quality Flow Rate = Q1 = (qu) (A) (WQV)

Structure Name	Q1 (cfs)	
DMH-1 (WQU-1)	0.24	Use Contech CDS Model 1515-3 (design flow = 1.0 cfs)(or approved equal)
DMH-2 (WQU-2)	0.22	Use Contech CDS Model 1515-3 (design flow = 1.0 cfs)(or approved equal)
DMH-5 (WQU-3)	0.22	Use Contech CDS Model 1515-3 (design flow = 1.0 cfs)(or approved equal)
DMH-8 (WQU-4)	0.19	Use Contech CDS Model 1515-3 (design flow = 1.0 cfs)(or approved equal)
DMH-12 (WQU-5)	0.37	Use Contech CDS Model 1515-3 (design flow = 1.0 cfs)(or approved equal)
DMH-15 (WQU-6)	0.46	Use Contech CDS Model 1515-3 (design flow = 1.0 cfs)(or approved equal)

Computation Sheet

Title *Pipe Sizing Table*
Project The Sanctuary - School Street - Manchester By the Sea - Comprehensive Permit
Date July 16, 2021
Revised March 23, 2022
A&M Project Number: 2725-01

Minimum Slope: 0.50%
Minimum Pipe Size: 6.00
Rainfall Intensity (in/hr): 6.18 (25 year storm)
Manning's n: 0.013 HDPE/PVC
Minimum Pipe Cover: 0.88

By DMR
Chk'd SJL
Apprv'd CMQ

Line						Req'd. Capac.	Pipe Size	Slope	Design Capacity		Drop	Invert Elevation		Rim Elev.	
From	**To**	**Length**	**Area**	**wgt. *C***	***C* A**	***Qd***	***D***	***s***	***Q full***	***V full***		**Upper**	**Lower**	**Upper**	**Cover**
Upper	**Lower**	**(feet)**	**(acres)**			(cfs)	(in)	(%)	(cfs)	(fps)	(feet)	(ft)	(ft)	(ft)	(ft)
CB-1	DMH1 (WQU1)	32	0.130	0.74	0.096	0.59	12	0.50%	2.5	3.21	0.16	50.24	50.08	52.50	1.14
CB-2	DMH1 (WQU1)	5	0.110	0.82	0.091	0.56	10	1.20%	2.4	4.40	0.06	50.14	50.08	52.50	1.40
DMH-1(WQU-1)	FES-1	15				1.33	12	0.53%	2.6	3.31	0.08	50.08	50.00	51.80	0.59
CB-3	DMH-2(WQU2)	6	0.101	0.95	0.096	0.59	12	5.00%	8.0	10.14	0.30	60.00	59.70	63.00	1.88
CB-4	DMH-2(WQU2)	19	0.101	0.95	0.096	0.59	12	2.00%	5.0	6.42	0.38	60.00	59.62	63.00	1.88
DMH-2(WQU2)	FES-2	36				1.58	12	2.00%	5.0	6.42	0.72	59.52	58.80	63.80	3.15
DMH-22(OCS)	DMH-23	120	(From HydroCAD 25-year storm)			4.87	18	0.50%	7.4	4.20	0.60	47.20	46.60	51.15	2.33
CB-5	FES-3	60	0.473	0.35	0.166	1.62	12	8.33%	10.3	13.10	5.00	63.50	58.50	67.50	2.88
CB-12	DMH-13	14	0.138	0.85	0.117	0.72	12	2.00%	5.0	6.42	0.28	111.01	110.73	116.90	4.77
CB-13	DMH-13	14	0.138	0.85	0.117	0.72	12	2.00%	5.0	6.42	0.28	111.01	110.73	116.90	4.77
DMH-13	DMH-14	77				1.45	12	1.00%	3.6	4.54	0.77	110.63	109.86	116.20	4.45
TD-1	DMH-14	44	0.115	0.95	0.109	0.67	6	2.00%	0.8	4.04	0.88	110.74	109.86	112.95	1.59
DMH-14	DMH-15(WQ6)	29				2.12	12	1.00%	3.6	4.54	0.29	109.76	109.47	113.50	2.61
CB-14	DMH-15(WQ6)	34	0.218	0.86	0.187	1.15	12	0.68%	2.9	3.73	0.23	109.70	109.47	111.70	0.88
DMH-15(WQ6)	DMH-16	83				3.27	15	1.00%	6.5	5.26	0.83	109.47	108.64	112.60	1.76
ROOF DRAIN	DMH-17	5	0.697	0.95	0.662	4.09	15	1.00%	6.5	5.26	0.05	106.56	106.51	112.50	4.57
DMH-17	DMH-18	21				7.36	18	1.00%	10.5	5.94	0.21	106.52	106.31	112.50	4.36
DMH-18	DMH-19	140				7.36	18	1.00%	10.5	5.94	1.40	106.21	104.81	112.50	4.67
DMH-19	DMH-20	88	0.119	0.61	0.073	7.36	18	1.00%	10.5	5.94	0.88	104.71	103.83	112.50	6.17
ROOF DRAIN	DMH-20	12	0.463	0.95	0.440	2.72	12	1.00%	3.6	4.54	0.12	103.84	103.72	113.50	8.54
DMH-20	DMH-21	118				10.08	18	1.00%	10.5	5.94	1.18	103.73	102.55	112.70	7.35
ROOF DRAIN	DMH-21	412	0.627	0.95	0.596	3.68	12	1.00%	3.6	4.54	4.12	106.56	102.44	125.00	17.32
DMH-21	DMH-10	85				13.76	24	1.00%	22.7	7.20	0.85	102.45	101.60	111.00	6.43

Computation Sheet

Title	***Pipe Sizing Table***	Minimum Slope:	0.50%	By	DMR
Project	The Sanctuary - School Street - Manchester By the Sea - Comprehensive Permit	Minimum Pipe Size:	6.00	Chk'd	SJL
Date	July 16, 2021	Rainfall Intensity (in/hr):	6.18 (25 year storm)	Apprv'd	CMQ
Revised	March 23, 2022	Manning's n:	0.013 HDPE/PVC		
A&M Project Number: 2725-01		Minimum Pipe Cover:	0.88		

Line						Req'd. Capac.	Pipe Size	Slope	Design Capacity		Drop	Invert Elevation		Rim Elev.	
From	**To**	**Length**	**Area**	**wgt. *C***	***C* A**	***Qd***	***D***	***s***	***Q** full*	***V** full*		**Upper**	**Lower**	**Upper**	**Cover**
Upper	**Lower**	**(feet)**	**(acres)**			(cfs)	(in)	(%)	(cfs)	(fps)	(feet)	(ft)	(ft)	(ft)	(ft)
DMH-7(OCS-1)	DMH-6	165	(From HydroCAD 25-year storm)			0.63	12	5.00%	8.0	10.14	8.25	101.50	93.25	112.20	9.58
CB-15	DMH-6	35	0.344	0.35	0.121	0.74	12	5.00%	8.0	10.14	1.75	97.00	95.25	99.80	1.68
DMH-6	DMH-4	194				1.37	12	4.80%	7.8	9.94	9.32	93.15	83.83	100.40	6.13
CB-6	DMH-5(WQU-3)	21	0.092	0.95	0.087	0.54	12	2.00%	5.0	6.42	0.42	85.00	84.58	88.00	1.88
CB-7	DMH-5(WQU-3)	9	0.092	0.95	0.087	0.54	12	5.00%	8.0	10.14	0.45	85.03	84.58	88.00	1.85
DMH-5(WQU-3)	DMH-4	15				1.08	12	7.53%	9.8	12.45	1.13	84.58	83.45	87.30	1.60
DMH-4	DMH-3	150				2.45	12	10.00%	11.3	14.35	15.00	83.35	68.35	89.00	4.53
DMH-3	FES-4	63				2.45	12	2.00%	5.0	6.42	1.26	59.76	58.50	76.50	15.62
CB-8	DMH-8(WQU4)	4	0.225	0.83	0.186	1.15	12	5.00%	8.0	10.14	0.20	103.80	103.60	106.80	1.88
CB-9	DMH-8(WQU4)	18	0.293	0.83	0.244	1.51	12	2.00%	5.0	6.42	0.36	103.96	103.60	106.80	1.72
DMH-8(WQU4)	DMH-9	17				2.66	12	2.00%	5.0	6.42	0.34	101.84	101.50	107.60	4.63
CB-10	DMH-12	16	0.259	0.80	0.206	1.27	12	2.00%	5.0	6.42	0.32	117.10	116.78	120.10	1.88
CB-11	DMH-12	24	0.259	0.80	0.206	1.27	12	2.00%	5.0	6.42	0.48	117.26	116.78	120.90	2.52
DMH-12	DMH-11	142				2.54	12	5.00%	8.0	10.14	7.10	116.78	109.68	119.50	1.60

SCHOOL STREET, Manchester-by-the-Sea, MA

Computation Sheet

By	SJL
Chk'd	CMQ
Apprv'd	CMQ

Title: ***RipRap Sizing Spreadsheet***
Project: The Sanctuary at Manchester-by-the-Sea
Date: March 23, 2022
Revised:
A&M Project Number: 2725-01

OUTLET	Do (ft.)	Q25 (cfs)***	Tw (ft.)	La (ft.)	Wup (ft.)	Wdn (ft.)**	d50 (ft.)*
FES-1	1.00	2.98	0.5	12.4	3.0	15.4	0.17
FES-2	1.00	1.12	0.5	9.0	3.0	12.0	0.05
FES-3	1.00	2.25	0.5	11.1	3.0	14.1	0.11
FES-4	1.00	0.63	0.5	8.1	3.0	11.1	0.02
FES-5	2.00	7.35	0.5	18.7	6.0	24.7	0.27

Notes:
Assume 6" Tw at Outfall
Use MHD M2.02.2 Stone
Depth of Stone to be 6" or 1.5 times d50 - which ever is larger

***6" Minimum Stone Diameter**
****Apron width shall meet defined downstream channel**
****See pipe sizing spreadsheet for Q25 flows**

When Tw < 0.5Do at pipe outlet:
La = 1.8Q/Do^1.5 + 7Do
Wup = 3Do
Wdn = 3Do + La
d50 = (0.02Q^1.3)/(TwDo)

When Tw > or = 0.5Do at pipe outlet:
La = 3Q/Do^1.5 + 7Do
Wup = 3Do
Wdn = 3Do + 0.4La
d50 = (0.02Q^1.3)/(TwDo)

Where:
Tw = the tailwater depth at the outlet of the pipe or channel
Do = the diameter of the pipe or the width of channel
Q = the discharge from the pipe of channel (25 year Storm)
La = the length of apron
Wup = the upstream width of apron
Wdn = the downstream width of apron
d50 = the median stone diameter

NJCAT TECHNOLOGY VERIFICATION

VortSentry® Stormwater Treatment System

December 2005

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1. Introduction

1.1 New Jersey Corporation for Advanced Technology (NJCAT) Program

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

- Advance policy strategies and regulatory mechanisms to promote technology commercialization;
- Identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated;
- Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state; and
- Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, suppliers have the competitive edge of an independent third party confirmation of claims.

Pursuant to N.J.S.A. 13:1D-134 et seq. (Energy and Environmental Technology Verification Program), the New Jersey Department of Environmental Protection (NJDEP) and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies the net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for review and decision-making of permits or approvals associated with the verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter into reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency (USEPA), other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and

- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the Energy and Environment Technology Verification Program.

1.2 Technology Verification Report

In October 2005, Stormwater360™, Inc., 200 Enterprise Drive, Scarborough, Maine, 04074, submitted a formal request for participation in the NJCAT Technology Verification Program. The technology proposed, The VortSentry® Stormwater Treatment System, is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows. The system was developed in Scarborough, Maine and is described in greater detail later in this report. Through research and field application, the technology has been refined to capture total suspended solids (TSS), sediments, oil and grease, and trash and debris (including floatables and negatively buoyant debris). The request (after pre-screening by NJCAT staff personnel in accordance with the technology assessment guidelines) was accepted into the verification program. This verification report covers the evaluation based upon the performance claim of the vendor, Stormwater360™, Inc. (see Section 4). The verification report differs from typical NJCAT verification reports in that final verification of the VortSentry® System (and subsequent NJDEP certification of the technology) awaits completed field testing that meets the full requirements of the Technology Acceptance and Reciprocity Partnership (TARP) – Stormwater Best Management Practice Tier II Protocol for Interstate Reciprocity for stormwater treatment technology. This verification report is intended to evaluate the Stormwater360™, Inc. initial performance claim for the technology based primarily on carefully conducted laboratory studies. This claim is expected to be modified and expanded following completion of the TARP required field-testing.

This project included the evaluation of assembled reports, company manuals, and laboratory testing reports to verify that the VortSentry® System meets the performance claim of Stormwater360™, Inc.

1.3 Technology Description

1.3.1 Technology Status

In 1990 Congress established deadlines and priorities for USEPA to require permits for discharges of stormwater that are not mixed or contaminated with household or industrial wastewater. Phase I regulations established that a NPDES (National Pollutant Discharge Elimination System) permit is required for stormwater discharge from municipalities with a separate storm sewer system that serves a population greater than 100,000 and certain defined industrial activities. To receive a NPDES permit, the municipality or specific industry has to develop a stormwater management plan and identify best management practices for stormwater treatment and discharge. Best management practices (BMPs) are measures, systems, processes or controls that reduce pollutants at the source to prevent the pollution of stormwater runoff discharge from the site. Phase II stormwater discharges include all discharges composed entirely of stormwater, except those specifically classified as Phase I discharge.

The nature of pollutants emanating from differing land uses are very diverse. Stormwater360™, Inc. has developed a technology for separating and retaining floating and sinking pollutants including sediment, hydrocarbons and debris under rapid flow conditions using a hydrodynamic separator. The system is designed with a circular treatment chamber that promotes a gentle swirling motion to encourage settling pollutants to migrate to the center of the chamber where they are deposited. Floating pollutants are elevated above the bottom of the baffle wall where they collect over time. Between maintenance events, pollutants accumulate within the system and are therefore removed from the natural environment. These pollutants may otherwise become a human health hazard, an aesthetic issue or may be cycled within the food chain or water table even if trapped in a land based treatment system. Maintenance is performed from above by a vacuum truck and without interference from internal components.

General

The VortSentry® Stormwater Treatment System is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows (See Figure 1). Stormwater flows enter the unit tangentially to the treatment chamber, which promotes a gentle swirling motion. As stormwater circles the treatment chamber, pollutants migrate toward the center of the unit where velocities are the lowest. Over time a conical pile tends to accumulate in the bottom of the treatment chamber containing sediment and associated metals, nutrients, hydrocarbons and other pollutants. Floating debris, oil and grease form a floating layer trapped in front of the treatment chamber baffle. These accumulated pollutants can be easily accessed through manholes conveniently located over the treatment chamber. Maintenance is typically performed through the manhole over the treatment chamber.

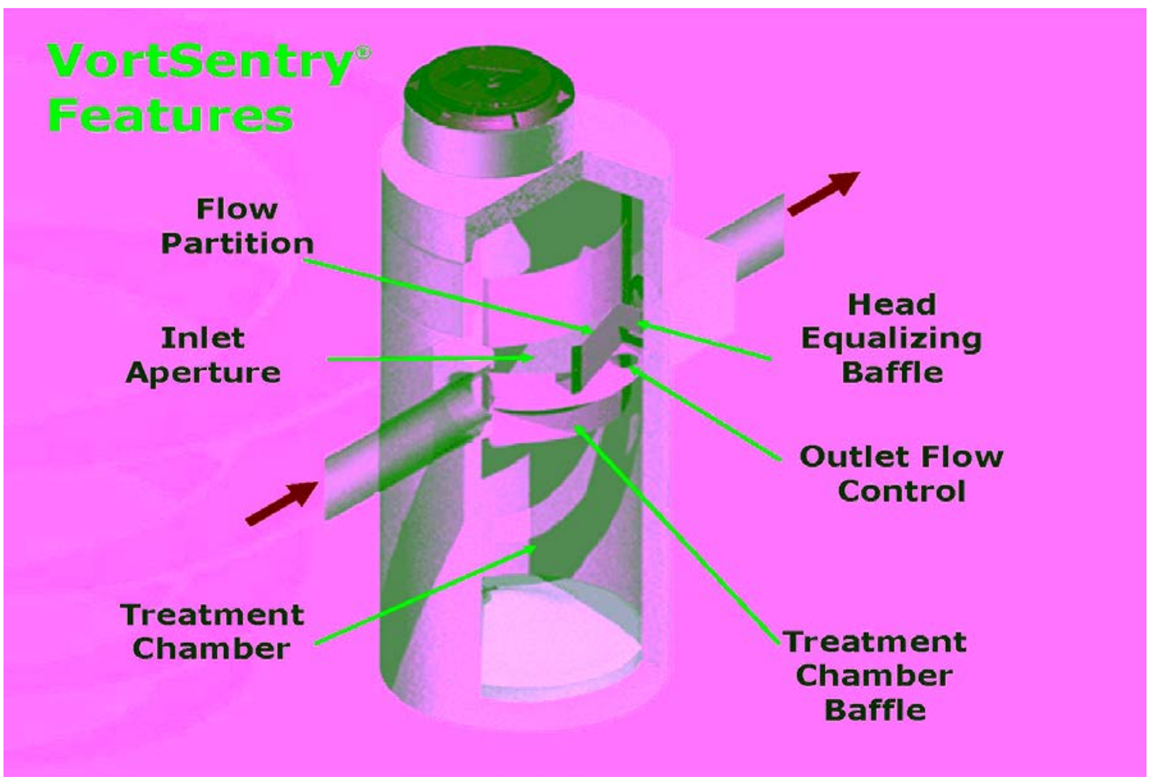

Figure 1. VortSentry® Features

1.3.2 Specific Applicability

The VortSentry® System is well suited to urban stormwater applications due to the following features:

- Laboratory testing has demonstrated that the system is capable of meeting stormwater treatment requirements;
- Below grade installation allows multiple land uses;
- Each system is custom designed to meet the hydraulic demands of site;
- Spill storage and sediment storage volumes can be increased as necessary;
- Technical support is available at no cost before and after the sale;
- There are no expendable or moving parts and a low cleanout volume minimizes operating costs.

The VortSentry® System is a compact, below grade system that is fabricated near the jobsite from concrete and marine grade aluminum. There are six standard precast models available, ranging from three to eight feet in diameter. In some regions VortSentry® systems are available in diameters up to 12 feet, but this is dependant on the capabilities of local precasters. Standard VortSentry® model sizes and dimensions are provided in Table 1.

Table 1. Standard VortSentry® Model Sizes and Dimensions

VortSentry® Model	Treatment Chamber Diameter		Depth (below invert)		Recommended Maximum Inlet / Outlet Pipe Size	
	(ft)	(m)	(ft)	(m)	(in)	(mm)
VS30	3	0.9	5.4	1.7	12	300
VS40	4	1.2	6.5	2.0	18	450
VS50	5	1.5	7.4	2.3	18	450
VS60	6	1.8	8.3	2.5	24	600
VS70	7	2.1	9.1	2.8	30	762
VS80	8	2.4	10.1	3.0	30	762

1.3.3 Range of Contaminant Characteristics

VortSentry® Systems have been shown to capture a wide range of pollutants of concern. These include: trash and debris (including floatables and negatively buoyant debris); total suspended solids; sediments; and oil and grease.

1.3.4 Range of Site Characteristics

Routine operation

Runoff from low intensity precipitation makes up the vast majority of the total annual flow volume from all sites. During low intensity precipitation events, all flow is diverted into the treatment chamber by the flow partition. The flow partition is designed to work in combination with the outlet flow control orifice to submerge the influent pipe during the water quality design storm. The effect of submerging the inlet pipe is to reduce inlet velocity and turbulence by increasing the cross sectional area of the flow path. Removal rates of sediment and floating pollutants are very high during routine operation since turbulence and internal velocities are very low, and residence times are relatively high. See Figure 2 for an illustration of routine VortSentry®operation.

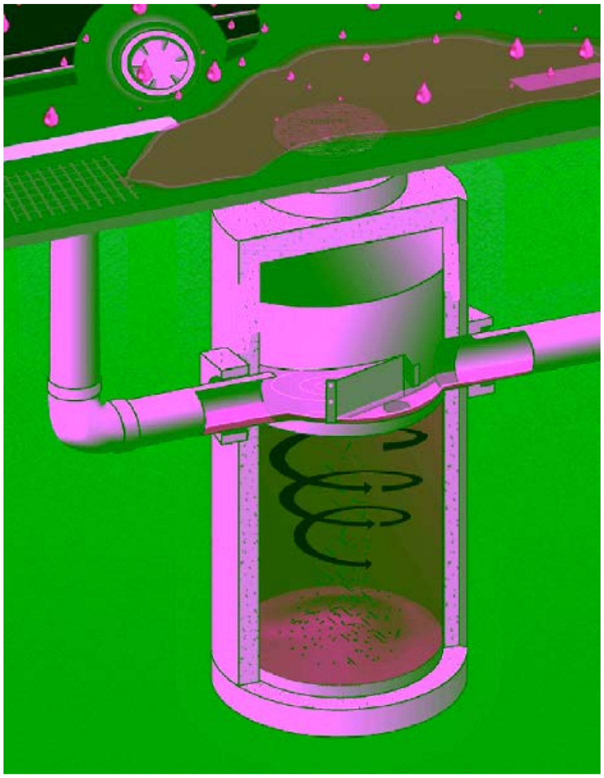

Figure 2. Routine VortSentry® Operation

Moderate intensity operation

As storm intensities and flow rates increase, the operating rate (gpm/ft3) in the VortSentry® also increases proportionally. At flow rates typical of moderate intensity storm events, a portion of flow begins to spill over the flow partition. Partitioning a portion of flow around the treatment chamber keeps velocities low in the treatment chamber. This allows the VortSentry® to continue to remove a high percentage of the pollutants from the runoff flowing through the treatment chamber. Maintaining low velocities in the treatment chamber also prevents scour of previously captured pollutants. The rising water surface elevation within the treatment chamber carries floating contaminants such as trash and oil and grease away from the inlet and above the bottom of the baffle wall. This effectively prevents re-entrainment by separating contaminants from the higher velocity zones within the system. The swirling action increases, which promotes the migration of particles toward the center of the treatment chamber where the particles then form a stable conical pile. See Figure 3 for an illustration of moderate intensity VortSentry® operation.

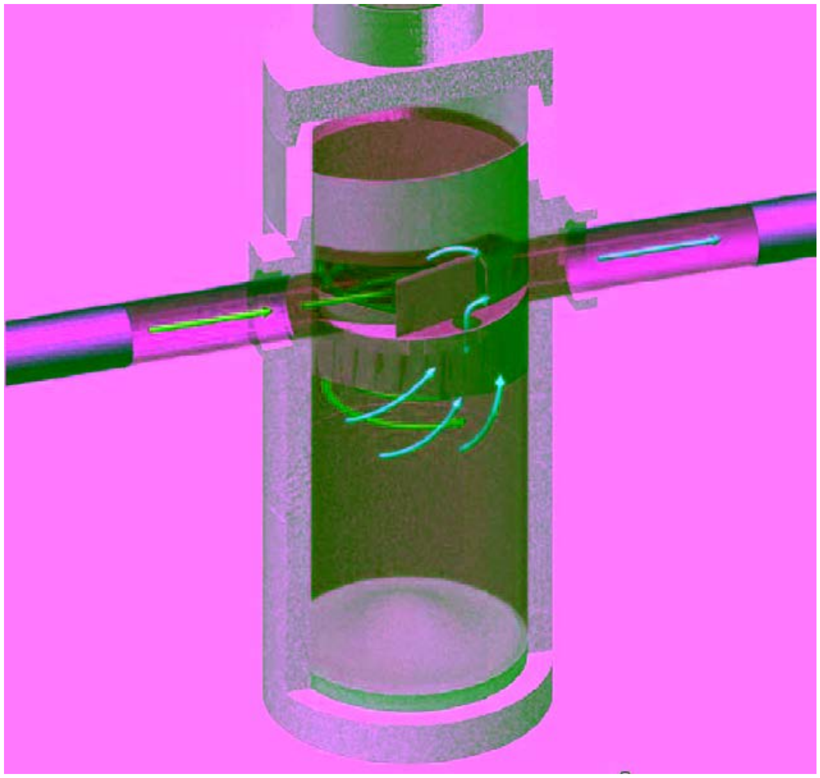

Figure 3. Moderate Intensity VortSentry® Operation

High Intensity Operation

At peak hydraulic capacity, the water surface elevation within the VortSentry® System increases and a substantial portion of the total flow passes over the flow partition submerging the head equalizing baffle. VortSentry® Systems are designed so that peak conveyance rates are representative of storm events such as the 5-yr or 10-yr rain event. Sediment and hydrocarbon removal rates are low, but previously captured materials remain trapped. This is accomplished by increasing the water surface elevation in the treatment chamber to isolate previously captured floatables and by maintaining low flow velocities in the treatment chamber. To accommodate large, infrequent storms, Stormwater360™, Inc. can also assist with the design of an external bypass to route peak-flows around the treatment unit.

Storm subsidence

As a storm subsides, treated runoff continues to flow out of the VortSentry® System through the outlet orifice until the water level returns to the dry-weather volume. This process typically takes several minutes after runoff has ceased.

1.3.5 Material Overview, Handling and Safety

Accumulated pollutants can easily be accessed through the manhole located above the treatment chamber. To clean out the VortSentry® System with a vacuum truck, it is generally most convenient and efficient to clean all captured pollutants including sediment, oil and grease, and floating debris through the manhole over the treatment chamber. Access to the treatment chamber is unrestricted making the vactor operation a simple task. Once the treatment chamber and captured pollutants have been vacuumed from the unit, the manhole cover is simply replaced to complete the maintenance event.

Solids recovered from the VortSentry® System can typically be land filled or disposed of at a wastewater treatment plant. It is possible that there may be some specific land use activities that create contaminated solids, which will be captured in the system. Such material would have to be handled and disposed of in accordance with hazardous waste management requirements.

1.4 Project Description

This project included the evaluation of assembled reports, company manuals, and laboratory testing reports to verify that VortSentry® Systems meet the performance claim of Stormwater360™, Inc.

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2. Evaluation of the Applicant

2.1 Corporate History

Stormwater Management, Inc. and Vortechnics, Inc. united as Stormwater360^{TM}, Inc. in April 2005. The two companies share over 25 years of experience in the stormwater industry. As a combined entity, their goal continues to be preserving and protecting water resources worldwide.

The joint company treats stormwater runoff from commercial, municipal and industrial sites, applying various technologies to address regulatory and customer requirements. Founded in 1988 and based in Scarborough, Maine, Vortechnics built their business on the development of hydrodynamic separation technology. Based in Portland Oregon, Stormwater Management led in the development of filtration technology, introducing a horizontal bed configuration with CSF leaf compost media in 1995.

In state-of-the-art laboratories at both locations, engineers and scientists continue to conduct research to further the understanding of nonpoint source pollution and develop practical product solutions. The parent company of Stormwater360^{TM}, Inc. is Contech Construction Products, Inc., a leading civil engineering site solutions products and services company involved in highway, drainage, sewage, and site-improvement. In 2004, Vortechnics was purchased by Contech; and in April 2005, Contech purchased Stormwater Management.

2.2 Organization and Management

The company Stormwater360^{TM}, Inc. is jointly headquartered in Scarborough, Maine, and Portland, Oregon with 19 regional sales offices throughout the United States and Canada. The management team consists of: David Miley, president and CEO; David Pollock, COO and VP of Sales; Jim Lenhart, Chief Technology Officer; Eric Roach, Chief Financial Officer; Fran Tighe, VP of Marketing; and Tom Gorrivan, National Sales Manager. The company has 23 regional sales managers, who report to Tom Gorrivan and work out of regional offices based in Maine, Maryland, Georgia, Texas, Ohio, California, Washington, Oregon, Wisconsin, Pennsylvania, Massachusetts, Nova Scotia, and Ontario.

2.3 Operating Experience with the Proposed Technology

Stormwater360^{TM}, Inc. has more than 15 years of experience with stormwater technology, and after several years of research and development the VortSentry® was released in 2003. Currently there are more than 300 installations throughout the United States and Canada. Most importantly, the technology is backed by years of full scale laboratory testing and rigorous field testing is ongoing, including third party studies from several universities and organizations.

2.4 Patents

Stormwater360™ has filed for patent protection for the VortSentry® System with the US Patent Office, and a patent is currently pending.

2.5 Technical Resources, Staff and Capital Equipment

Stormwater360™ completes all design work at its corporate headquarters in Scarborough, Maine and Portland, Oregon. Once a system design is complete, shop drawings are issued to a precast concrete contractor local to the installation site. Representatives from each precast company are trained in VortSentry® construction to ensure the details of construction are properly executed. Different contractors may elect to cast the system differently depending on their equipment and construction capabilities. For example, a precaster would have input regarding the details of construction such as how many pieces per system. They would also determine how the joints are formed and what type of lifting equipment is cast in. Stormwater360™, Inc. ultimately reviews all construction and installation decisions made by the precaster.

The VortSentry® System is delivered to the site by the precaster on the day of installation. VortSentry® systems typically arrive on site in three or more pieces and require some assembly. VortSentry® models VS30-VS50 typically do not require the use of a crane for installation. Once delivered to the site by the precaster the contractor is responsible for assembling and sealing the VortSentry® sections. VortSentry® models VS60 and larger typically require a crane for installation and additional sealing of the aluminum components onsite. The site contractor is responsible for making arrangements to have a crane on site, completing excavation prior to delivery and setting the system into the ground. The contractor is also responsible for grouting the inlet and outlet pipe into the VortSentry® System, backfilling around the system and bringing the manhole frames and covers up to grade. Any work required on components inside the system is typically the responsibility of the Stormwater360™ precast contractor. Installation for all model sizes can typically be completed in two to four hours. Heaviest pick weight will be confirmed by Stormwater360™ staff and communicated to the contractor prior to delivery.

Specific installation instructions and requirements are provided. Stormwater360™ tries to have a representative onsite during installation, but occasionally this is not possible. However, support representatives are always available to address questions that may arise during installation.

When the system arrives on site, it is inspected by the contractor. Any damage due to shipping and handling up to that point must be corrected by the precaster. Once the contractor takes delivery of the unit, it is their responsibility to lift it from the truck, place it in the ground, and connect the inlet and outlet pipes and backfill around it. The contractor will perform a final check against the VortSentry® Specification and the site plan before backfilling is initiated. If there are any installation errors at that point, the contractor will fix them and the system will be back filled.

Adjustments for buoyancy issues, calculation of pick weights, and other custom design items are confirmed before delivery. The inlet and outlet are clearly marked to avoid improper installation. It is especially important that the system be set in such a way that the inlet pipe is at a 90 degree angle to the side of the tank to encourage proper treatment chamber flow dynamics. This orientation is checked prior to backfilling the unit since a significantly different influent pipe angle may increase inlet turbulence or cause short-circuiting of the treatment chamber.

VortSentry® Systems are typically available within four to six weeks of shop drawing approval.

3. Treatment System Description

The VortSentry® Stormwater Treatment System was designed to capture a wide range of pollutants from stormwater including: trash and debris (including floatables and negatively buoyant debris); total suspended solids; sediments; and oil and grease. Figure 1 displays a simple schematic of the VortSentry® System. The VortSentry® is a compact, below grade stormwater treatment system that employs vortex technology to enhance gravitational separation of floating and settling pollutants from stormwater flows. The device has no moving parts and is fabricated from concrete and marine grade aluminum. The main components of the system are a flow partition, inlet aperture, head equalizing baffle, treatment chamber, outlet flow control orifice, and treatment chamber baffle. The system is also equipped with a manhole for easy inspection and maintenance access.

During operation, stormwater runoff enters the unit tangentially to promote a gentle swirling motion in the treatment chamber. As polluted water circles within the chamber, settleable solids fall into the sump and are retained. Buoyant debris and oil and grease rise to the surface and are separated from the water as it flows under the baffle wall. Finally, treated water exits the treatment chamber through a flow control orifice located behind the baffle wall.

During low-flow conditions, all runoff is diverted into the treatment chamber by the flow partition. At higher flow rates, a portion of the runoff spills over the flow partition and is diverted around the treatment chamber to prevent re-suspension and washout of previously trapped pollutants. Water that spills over the partition flows into the head equalization chamber above the treatment chamber outlet. As the head equalization chamber fills, the head differential driving flow through the treatment chamber collapses. The result is that flow rates in the treatment chamber remain relatively constant even as total flow rates increase substantially. This configuration further reduces the potential for re-suspension or washout.

There are typically six (6) precast VortSentry® System models available to meet the hydraulic and water quality needs of large and small projects (See Table 1). The VortSentry® Systems have the ability to treat a wide range of flows. In certain regions, larger systems are available to accommodate higher flow rates.

4. Technical Performance Claim

Claim - The VortSentry® Stormwater Treatment System, Model VS40, sized at a loading rate of 9.8 gpm/ft^3 (0.022cfs/ft^3) of treatment volume, has been shown to have a 69% total suspended solids (TSS) removal efficiency, as measured as suspended solids concentration (SSC) (as per the NJDEP methodology for calculation of treatment efficiency) for F-95 silica sand with an average d_{50} particle size of 120 microns, an average influent concentration of 209 mg/L and 50% initial sediment loading in laboratory studies using simulated stormwater.

5. Treatment System Performance

The VortSentry® System has been tested at the Stormwater360™, Inc. full-scale hydraulic laboratory. The laboratory tests were completed using F-95, a commercially available silica sand gradation. The particle size distribution is shown in Figure 4. Tests were performed with sediment influent concentrations ranging from 88 to 521 mg/l at operating rates from 0.27 to 1.35 cfs. In addition to specific testing, Stormwater360™, Inc. has developed the Rational Rainfall Method™, a model that estimates long term field performance based on site information, local precipitation patterns and laboratory performance data. The VortSentry® System is currently being tested in the field by Stormwater360™, Inc. staff as well as by independent researchers.

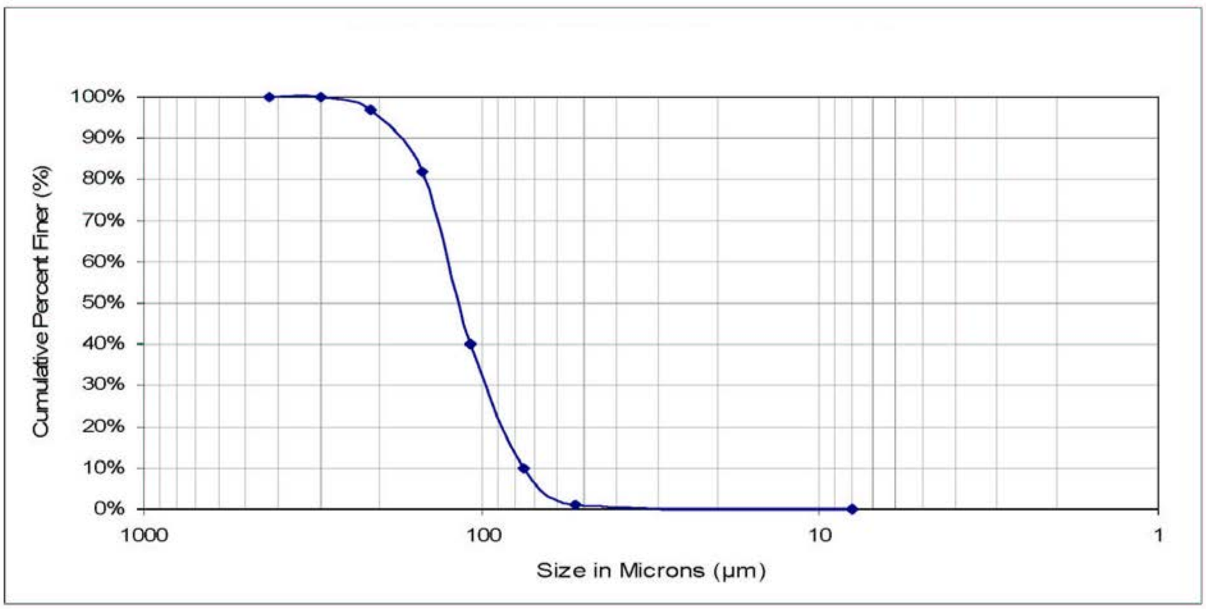

Figure 4. US Silica F-95 Particle Size Distribution

5.1 NJDEP Recommended TSS Laboratory Testing Procedure

Stormwater360™, Inc. designed their laboratory testing to comply with NJDEP's recommended TSS Laboratory Testing Procedure; the NJDEP testing procedure is presented herein. The NJDEP has prepared a Total Suspended Solids Laboratory Testing Procedure to help guide vendors as they prepare to test their stormwater treatment systems prior to applying for NJCAT verification.

The Testing Procedure has three components:

1. Particle size distribution

2. Full scale laboratory testing requirements
3. Measuring treatment efficiency

1. Particle size distribution:

The following particle size distribution was utilized to evaluate a manufactured treatment system (See Table 2). A natural/commercial soil representing the USDA definition of a sandy loam material was used. This hypothetical distribution was selected as it represents the various particles that would be associated with typical stormwater runoff from a post construction site.

Specifically, the following distribution can be utilized:

Table 2. Particle Size Distribution

Particle Size (microns)	Sandy loam (percent by mass)
500-1000 (coarse sand)	5.0
250-500 (medium sand)	5.0
100-250 (fine sand)	30.0
50-100 (very fine sand)	15.0
2-50 (silt)	(8-50 um, 25%) (2-8 um, 15%)*
1-2 (clay)	5.0

Notes:

1. Recommended density of particles ≤2.65 g/cm3

*The 8 um diameter is the boundary between very fine silt and fine silt according to the definition of American Geophysical Union. The reference for this division/classification is: Lane, E. W., et al. (1947), "Report of the Subcommittee on Sediment Terminology," Transactions of the American Geophysical Union, Vol. 28, No. 6, pp. 936-938.

2. Full scale lab test requirements
   A. At a minimum, complete a total of 15 test runs including three (3) tests each at a constant flow rate of 25, 50, 75, 100, and 125 percent of the treatment flow rate. These tests should be operated with initial sediment loading of 50% of the unit's capture capacity.
   B. The three tests for each treatment flow rate will be conducted for influent concentrations of 100, 200, and 300 mg/L.
   C. For an online system, complete two tests at the maximum hydraulic operating rate. Utilizing clean water, the tests will be operated with initial sediment loading at 50% and 100% of the unit's capture capacity. These tests will be utilized to check the potential for TSS resuspension and washout.
   D. The test runs should be conducted at a temperature between 73-79 degrees Fahrenheit or colder.

3. Measuring treatment efficiency
   A. Calculate the individual removal efficiency for the 15 test runs.
   B. Average the three test runs for each operating rate.

C. The average percent removal efficiency will then be multiplied by a specified weight factor (see Table 3) for that particular operating rate.
D. The results of the five numbers will then be summed to obtain the theoretical annual TSS load removal efficiency of the system.

Table 3. Treatment Operating Rates and Weight Factors

Treatment operating rate	Weight factor
25%	.25
50%	.30
75%	.20
100%	.15
125%	.10

Notes:

Weight factors were based upon the average annual distribution of runoff volumes in New Jersey and the assumed similarity with the distribution of runoff peaks. This runoff volume distribution was based upon accepted computation methods for small storm hydrology and a statistical analysis of 52 years of daily rainfall data at 92 rainfall gages.

5.2 Laboratory Studies

In June of 2005, Stormwater360™ initiated a VortSentry® laboratory testing program in accordance with the New Jersey Department of Environmental Protection's (NJDEP) Total Suspended Solids Laboratory Test Procedure. All testing was conducted in the Stormwater360™ laboratory in Scarborough, ME on a full scale 4-ft diameter VortSentry® model VS40. The ultimate objective of the testing program was to provide a sufficient body of performance data to warrant an interim certification from the NJDEP. In order to comply with the requirements of the NJDEP testing protocol and to provide a data set that is comparable to the data sets of other stormwater treatment technologies that have completed the Tier I testing program, Stormwater360™ modeled its VortSentry® test plan to be consistent with the test plans for other technologies that have participated in the Tier I testing program.

All testing was conducted using F-95, a commercially available silica sand gradation (See Figure 4). Sediment was mixed with tap water in a 55-gallon recirculating slurry bin. A peristaltic pump was utilized to meter the slurry mixture into the influent line upstream of the test apparatus at a known rate.

Influent samples were collected at a 6-inch gate valve located upstream of the VortSentry® System. Effluent samples were collected by sweeping a sample bottle through the free discharge of a down-turned 90° PVC elbow, which discharges into a catch tank downstream of the VortSentry® System. All samples were collected in 500 ml HDPE sample bottles. Once the system was stabilized at the desired flow rate the metering pump was activated, starting the delivery of sediment to the VortSentry® System. Once sediment introduction was initiated, the system was run for a period of time equal to three times the detention time of the system before the first samples were collected. This allows the system to reach equilibrium. After three detention times have passed, a series of ten paired influent and effluent samples were taken at one minute intervals. Effluent samples were staggered from influent samples by the detention time of the test unit. Once ten influent and effluent samples were collected, the system was shut down. Sediment was not removed from the test system after each test effectively allowing additional sediment to accumulate within the treatment chamber sump.

To reduce recirculation of material within the test system, a silt fence was constructed in the catch tank to filter the effluent before it was pumped back to the water supply tank. Background samples were drawn from the water supply tank using a GLI Automatic Vacuum Sampler to monitor the sediment concentration in the source water. If the mean sediment concentration in the source water exceeded 10 mg/l during a test, the water supply tank was drained and cleaned, and the test was then repeated.

5.2.1 Performance Testing Procedure

1. Prior to the start of each test, the VortSentry® System was filled to 50% of its sediment capture depth (1.5ft) with F-95 sediment.
2. A sediment/water slurry was prepared in a ratio of 1.25 lb of sediment/gallon of water in the slurry mixer.
3. Adequate mixing was ensured by starting the slurry mixture at least five minutes before the start of the sediment metering pump.
4. The inlet flow control valve was opened and the flow rate through the VortSentry® System was stabilized at the target flow rate. The system was considered stable when the flow rate remained stable for approximately one minute.
5. The metering pump was started at the target rpm rate (rate required to produce target influent concentration). This was time 0:00.
6. After three detention times, the first background sample was collected. Background samples were collected at a one minute interval for the duration of the test.
7. One minute after the first background sample was taken, the first influent sample was collected. Influent samples were collected at one minute intervals until ten samples are taken.

   Note: Immediately before each influent sample was taken, the gate valve was flushed by quickly opening and closing it. This cleared any settled material from the mouth of the valve.
8. One detention time after the first influent sample was taken, the first effluent sample was collected.
9. Effluent samples were collected at a one minute interval until ten samples were taken.
10. After ten influent and effluent samples were collected, the metering pump and slurry tank mixer were stopped.
11. The background sampler was then stopped.
12. The VortSentry® System was shut down.

5.2.2 Washout Testing Procedure

Upon completion of the required performance testing, two washout trials were conducted to determine the potential for material to be scoured from the VortSentry® System. The first trial was conducted with the VortSentry® model VS40 filled to 50% (19 ft^3) of its sediment capture volume with F-95. The second trial was conducted with the VortSentry® System filled to 100% (38 ft^3) of its sediment capture volume. Both of these trials were conducted at the system's peak hydraulic capacity. Both trials were conducted with clean water. No sediment was injected into the influent stream. Upon start up, the system was brought to its peak operating capacity. Effluent sampling was started as soon as flow was introduced to the unit and continued in 30-second intervals until the conclusion of the test. Sampling before the unit had reached its hydraulic capacity was allowed for documentation of any material that was scoured before the VortSentry® System reaches hydraulic capacity. Once the system had reached hydraulic capacity, sampling continued in 30 second intervals for five minutes. Given the relatively short detention time of the unit under peak operating conditions, this was ample time to determine the unit's scour potential.

5.2.3 Sample Analysis

Sample analysis was conducted at the Stormwater360™, Inc. laboratory by trained laboratory technicians. Samples were analyzed in compliance with ASTM D 3977-97 a whole sample variation of the TSS method, also referred to as the suspended sediment concentration (SSC) method.

5.2.4 Description of Laboratory Testing Facility

All VortSentry® System performance testing was conducted at the Stormwater360™, Inc. research laboratory in Scarborough, Maine. Water was stored in a 5,600 gallon supply tank and delivered to the VortSentry® System through a gravity fed 12-inch diameter PVC pipe. Flow through the pipe was regulated by a 12 inch butterfly valve located upstream of the VortSentry® System. A 1/3 horse power Dayton split phase motor was used to mix sediment and water into a slurry in a 55 gallon conical bottom mixing bin. The slurry was then metered into the 12 inch PVC pipe just downstream of the butterfly valve with a Watson Marlow peristaltic pump. The conical bottom slurry tank was equipped with an under drain which remained open during the test to allow the slurry to be continuously recirculated within the bin with a Randolph Model 750 peristaltic pump. Influent samples were collected through a 6 inch PVC gate valve located directly downstream of the sediment metering port. Flow was monitored with an ISCO 4250 Area Velocity flow meter that was installed in the influent pipe. Effluent discharged from a down turned 12 inch PVC elbow into an aluminum catch tank. A silt fence, consisting of standard landscaping fabric mounted to a frame, was installed in the catch tank to filter effluent before it was recirculated to the water supply tank. Two ten horsepower Zoeller sewage pumps returned flow from the catch tank to the supply tank. The layout of the VortSentry® System test setup is shown in Figure 5.

5.2.5 Laboratory Testing Results

Results of the 15 individual tests conducted in accordance with the NJDEP laboratory testing protocol are summarized in Table 4. The target flow rate for each test was determined assuming the target treatment flow rate was 1.1 cfs. The target treatment flow rate was identified through preliminary testing to gauge system performance. The actual flow rate as reported in Table 4 represents the mean flow rate measured during each test. The removal efficiency reported for each test represents the mean suspended solids load reduction for that test and is calculated using the following equation:

Removal Efficiency = (Influent Conc. – Effluent Conc.) / Influent Conc.

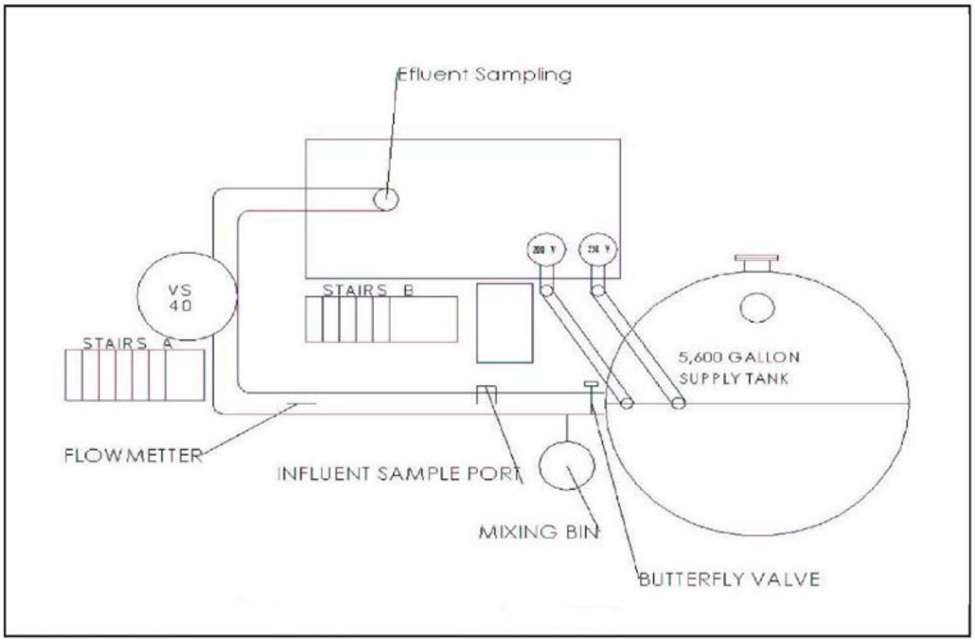

Figure 5. Laboratory Testing Facility for the VortSentry® System

Table 4. Summary of VortSentry® Laboratory Testing Results with F-95 Grade Silica

Test Number	Percent of Treatment Flow (%)	Target Flow Rate (cfs)	Target Conc. (mg/l)	Actual Flow Rate (cfs)	Influent Conc. (mg/l)	Effluent Conc. (mg/l)	Removal Efficiency (%)
1	25	0.27	100	0.27	88	6	93
2	25	0.27	200	0.27	200	12	94
3	25	0.27	300	0.26	266	13	95
4	50	0.55	100	0.56	92	23	75
5	50	0.55	200	0.54	219	60	73
6	50	0.55	300	0.54	521	121	77
7	75	0.82	100	0.84	130	44	66
8	75	0.82	200	0.83	142	53	63
9	75	0.82	300	0.81	304	122	60
10	100	1.10	100	1.11	95	49	48
11	100	1.10	200	1.10	167	80	52
12	100	1.10	300	1.09	277	164	41
13	125	1.35	100	1.35	137	102	26
14	125	1.35	200	1.24	233	163	30
15	125	1.35	300	1.35	263	179	32

5.2.6 Washout Testing Results

As required by the NJDEP laboratory testing protocol, a washout analysis was conducted at both 50 and 100 percent of the VortSentry® System sediment storage capacity. The protocol required each trial to be conducted at the maximum hydraulic operating rate of the unit. Due to the driving head limitations of the water supply tank in the laboratory, the maximum hydraulic operating rate for the model VS40 VortSentry® System was approximately 1.8 cfs. A VortSentry® model VS40 can be configured with additional hydraulic capacity, but this additional flow was directed over the flow partition and did not significantly impact the flow rate or velocity of flow through the treatment chamber. By limiting the flow rate and velocity through the treatment chamber, resuspension of previously captured material is unlikely.

The mean flow rate for the washout tests at both 50 and 100 percent of sediment storage capacity was 1.77 cfs. Results for both tests are shown in Table 5. During both tests the sediment concentration in the source water was monitored and subtracted from the VortSentry® System effluent concentration. Solids in the source water are typically attributable to recirculation of material during previous tests. With the sump filled to 50 percent of the VortSentry® System sediment storage capacity (1.5 feet), no washout was observed. The mean effluent concentration for suspended solids was less then the mean background concentration indicating a net removal of solids from the source water as it passed through the VortSentry® System. With the sump filled to 100 percent of the VortSentry® System sediment storage capacity (three feet), minimal washout was observed. The mean effluent concentration for suspended solids was slightly higher then the mean background concentration indicating a small amount of material was exported from the system. The mean effluent solids concentration after accounting for background solids was 8 mg/l, which is quite low; fine particles were present in the F-95 stock as a result of manufacture and handling. Most of the sediment was manually loaded into the VortSentry® System for this testing as opposed to being captured by the unit, so it is likely that residual fine material that would not typically be present in the sump was subsequently lost from the unit.

Table 5. Results of Washout Testing at 50% and 100% of the VortSentry® Sediment Storage Capacity

	Average Background Concentration (mg/l)	Average Effluent Concentration (mg/l)	Mean Adjusted Effluent Concentration (mg/l)
50% of sediment storage capacity (1.5 ft)	8	5	-3
100% of sediment storage capacity (3 ft)	5	14	8

5.3 Verification Procedures

All the data provided to NJCAT were reviewed to fully understand the capabilities of the VortSentry® System. To verify the Stormwater360™, Inc. claim, the laboratory data were reviewed and compared to the NJDEP Laboratory Testing Protocol. Although Stormwater360™, Inc. attempted to design their laboratory experiment to satisfy the NJDEP TSS laboratory testing protocol, there are two distinct differences between Stormwater360™, Inc. laboratory testing and the NJDEP protocol. The NJDEP protocol is for total suspended solids (TSS) laboratory testing, while Stormwater360™, Inc. analyzed their samples as suspended sediment concentration (SSC). Also, the d_{50} of the NJDEP recommended sediment is approximately 67 microns, while the d_{50} of the F-95 silica used in the Stormwater360™, Inc. laboratory testing was 120 microns.

The NJDEP weighting factors were used with the laboratory data that were presented in Table 4. The resulting overall removal efficiency based upon the NJDEP methodology is presented below in Table 6.

Since the treatment volume of the VS40 system is 50 ft^3, the tested flow rate of 1.1 cfs can be converted to 9.8 gpm/ft^3(0.022 cfs/ft^3). Based upon the data presented in Table 6, the removal efficiency of the system is 69%, thereby verifying the Stormwater360™, Inc. claim.

Based upon the wash out laboratory data presented by Stormwater360™, Inc., there is virtually no potential of re-suspension and wash out of sediment contained in the VortSentry® System.

Table 6. Weighted Removal Efficiency for the VortSentry® System

Percent of Treatment Flow Rate (%)	Target VS40 Flow Rate (cfs)	Removal Efficiency (%)	Weight factor	Weighted Removal Efficiency (%)
25	0.27	94	0.25	24
50	0.55	75	0.30	22
75	0.82	63	0.20	13
100	1.10	47	0.15	7
125	1.35	29	0.10	3
Weighted Removal Efficiency =				**69**

5.3.1 Verified Treatment Flow

In order to appropriately scale any hydraulic structure, there must be similitude between the proposed model and the tested laboratory prototype. Geometric similitude is achieved by maintaining a constant aspect ratio of 0.9 for all models. For modeling purposes, the treatment depth is considered to be the distance from the top of the flow partition to the top of the 3' deep storage sump.

It has been shown in the laboratory that VortSentry® removal rates are dependent on the volumetric operating rate. Therefore, treatment flow rates for models other than the tested unit have been calculated which provide the same volumetric operating rate of 9.8 gpm/ft^3 (0.022 cfs/ft^3). Table 7 shows these peak treatment flow rate for each VortSentry® model.

Table 7. VortSentry Treatment Flows Assuming Volumetric Scaling

Model Number	Diameter (ft)	Treatment Volume (ft^3)	Treatment Flow Rate		Operating Rate	
			(cfs)	(gpm)	(cfs/ft^3)	(gpm/ft^3)
VS30	3	21	0.46	207	0.022	9.8
VS40	4	50	1.1	494	0.022	9.8
VS50	5	98	2.15	965	0.022	9.8
VS60	6	170	3.71	1,665	0.022	9.8
VS70	7	269	5.90	2,648	0.022	9.8
VS80	8	402	8.80	3,950	0.022	9.8
VS100*	10*	785	17.19	7,715	0.022	9.8
VS120*	12*	1,357	29.70	13,330	0.022	9.8

* 10 and 12 ft. diameter units are not available in all markets.

5.4 Inspection and Maintenance

The VortSentry® System requires minimal routine maintenance. However, it is important that the system be inspected at regular intervals and cleaned when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more on site activities than the size of the unit (i.e., heavy winter sanding will cause the treatment chamber to fill more quickly but regular sweeping will slow accumulation).

5.4.1 Inspection

Inspection is the key to effective maintenance, and it is easily performed. Stormwater360™, Inc. recommends ongoing quarterly inspections of accumulated pollutants. Sediment accumulation may be especially variable during the first year after installation as catch basin sumps are filled and as construction disturbances and landscaping stabilize. Quarterly inspections are typically sufficient to ensure that systems are cleaned out at the appropriate time. Inspections may need to be performed more often in the winter months in climates where sanding operations may lead to rapid accumulations or in other areas with heavy sediment loading. It is very useful to keep a record of each inspection.

The VortSentry® System should be cleaned when inspection reveals that the sediment depth has accumulated to three feet in the treatment chamber sump. This determination can be made by taking two measurements with a stadia rod or similar measuring device. One measurement should be taken from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. The system should be cleaned out if the difference between the two measurements is three feet or more.

Note: To avoid underestimating the volume of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile may offer less resistance to the end of the rod than larger particles toward the bottom of the pile.

5.4.2 Maintenance

Maintaining the VortSentry® System is easiest when there is no flow entering the system. For this reason it is a good idea to schedule the cleanout during dry weather. Cleanout of the VortSentry® System with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. If such a truck is not available, a “clamshell” grab may be used, but it is difficult to remove all accumulated pollutants with these devices.

Accumulated sediment is typically evacuated through the manhole over the treatment chamber. Simply remove the cover and insert the vacuum hose into the treatment chamber. All contents of the treatment chamber should be removed with the vacuum hose. The treatment chamber will contain a combination of liquid, sediment, floating debris, and oil and grease.

Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually cheaper to dispose of than the oil water emulsion that may be created by vacuuming the oily layer. In VortSentry® System installations where there is little risk of petroleum spills, liquid contaminants may not accumulate as quickly as sediment. However, any oil or gasoline spill should be cleaned out immediately. Trash can be netted out if it needs to be separated from the other pollutants.

Manhole covers should be securely seated following cleaning activities, to ensure that surface runoff does not leak into the unit from above.

5.4.3 Solids Disposal

Solids recovered from the VortSentry® System can typically be land filled or disposed of at a wastewater treatment plant, but local regulations will ultimately govern disposal procedures.

5.4.4 Damage Due to Lack of Maintenance

It is unlikely that the VortSentry® System will become damaged due to lack of maintenance since there are no fragile internal parts. However, adhering to a regular maintenance plan ensures optimal performance of the system.

6. Technical Evaluation Analysis

6.1 Verification of Performance Claim

Based on the evaluation of the results from laboratory studies, sufficient data is available to support the Stormwater360™, Inc. claim: The VortSentry® Stormwater Treatment System, Model VS40, sized at a loading rate of 9.8 gpm/ft^3 (0.022cfs/ft^3) of treatment volume, has been shown to have a 69% total suspended solids (TSS) removal efficiency, as measured as suspended solids concentration (SSC) (as per the NJDEP methodology for calculation of treatment efficiency) for F-95 silica sand with an average d_{50} particle size of 120 microns, an average influent concentration of 209 mg/L and 50% initial sediment loading in laboratory studies using simulated stormwater.

6.2 Limitations

6.2.1 Factors Causing Under-Performance

If the VortSentry® System is designed and installed correctly, there is minimal possibility of failure. There are no moving parts to bind or break, nor are there parts that are particularly susceptible to wear or corrosion. Lack of maintenance may cause the system to operate at a reduced efficiency, and it is possible that eventually the system will become totally plugged with sediment.

6.2.2 Pollutant Transformation and Release

The VortSentry® System will not increase the net pollutant load to the downstream environment. However, pollutants may be transformed within the unit. For example, organic matter may decompose and release nitrogen in the form of nitrogen gas or nitrate. These processes are similar to those in wetlands but probably occur at slower rates in the VortSentry® System due to the absence of light and mixing by wind, thermal inputs and biological activity. Accumulated sediment will not be lost from the system under normal operating conditions.

6.2.3 Sensitivity to Heavy or Fine Sediment Loading

The VortSentry® System requires no pretreatment. Heavy loads of sediment will increase the needed maintenance frequency but will not negatively affect overall performance.

6.2.4 Bypass Flow

The VortSentry® System is typically designed such that a portion of the total conveyance flow through the system is bypassed around the treatment chamber. Flow rates exceeding the treatment capacity of the system are typically routed around the treatment chamber over the flow partition.

6.2.5 Mosquitoes

The VortSentry® System design incorporates standing water in the treatment chamber sump, which can be a breeding site for mosquitoes. To address this potential problem Stormwater360™ sells an optional manhole cover insert that allows outgassing but will prevent mosquitoes from entering the system through the manhole covers. A flap valve can be installed at the terminal end of the outlet pipe to prevent mosquitoes from entering the unit from the downstream side.

7. Net Environmental Benefit

The NJDEP encourages the development of innovative environmental technologies (IET) and has established a performance partnership between their verification/certification process and NJCAT's third party independent technology verification program. The NJDEP, in the IET data and technology verification/certification process, will work with any company that can demonstrate a net beneficial effect (NBE) irrespective of the operational status, class or stage of an IET. The NBE is calculated as a mass balance of the IET in terms of its inputs of raw materials, water and energy use and its outputs of air emissions, wastewater discharges, and solid waste residues. Overall the IET should demonstrate a significant reduction of the impacts to the environment when compared to baseline conditions for the same or equivalent inputs and outputs.

Once VortSentry® Systems have been certified for interim use within New Jersey, Stormwater360™, Inc. will then proceed to install and monitor systems in the field for the purpose of achieving goals set by the Tier II Protocol and final certification. At that time, a net environmental benefit evaluation will be completed. However, it should be noted that the Stormwater360™, Inc. technology requires no input of raw material, has no moving parts, and therefore, uses no water or energy.

8. References

Patel, M. 2003, *Draft Total Suspended Solids Laboratory Testing Procedures*, December 23, 2003, New Jersey Department of Environmental Protection, Office of Innovative Technology and Market Development.

Stormwater360™, Inc., October 2005, VortSentry® Stormwater Treatment System Technology Report, *Prepared for: New Jersey Corporation for Advanced Technology.*

Stormwater360™, Inc., October 2005, VortSentry® Technical Design Manual.

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Bureau of Nonpoint Pollution Control
Division of Water Quality
Post Office Box 029
Trenton, New Jersey 08625-029
609-633-7021 Fax: 609-984-2147
http://www.state.nj.us/dep/dwq/bnpc_home.htm

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Acting Commissioner

Derek Berg
Regulatory Manager – Stormwater
CONTECH Engineered Solutions
200 Enterprise Drive
Scarborough, ME 04074

Re: Final Certification
Continuous Deflective Separator (CDS) by CONTECH Engineered Solutions LLC

Expiration Date: December 1, 2016
TSS Removal Rate: 50%

Dear Mr. Berg:

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7(c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). CONTECH Engineered Solutions LLC has requested a Final Certification for the Continuous Deflective Separator (CDS) Stormwater Treatment System.

This project falls under the July 15, 2011 "Transition for Manufactured Treatment Devices," under *C. Manufactured Treatment Devices Seeking Final Certification – In Process* which are MTDs that have commenced field testing on or before August 1, 2011.

NJDEP received the required information and signed statements by the NJCAT Technical Director and the manufacturer indicating that the requirements of the Field Testing Protocols in place at the initiation of testing have been met or exceeded. The NJCAT letter also includes a recommended certified TSS removal rate and the required maintenance plan.

The NJDEP certifies the use of the CONTECH Engineered Solutions LLC CDS Stormwater Treatment System at a TSS removal rate of 50%, subject to the following conditions:

1. The various models and associated water quality flow capacities shall be sized for the peak flow of the New Jersey Water Quality Design Storm per N.J.A.C. 7:8-5, as shown in Table 1 below.

New Jersey Treatment Rates for CDS Models Based on a Surface Area Secific Loading Rate of 25.16gpm/ft^2		
CDS Model	Manhole Diameter (ft)	Treatment Flow Rate (cfs)
CDS-4	4	0.7
CDS-5	5	1.1
CDS-6	6	1.6
CDS-8	8	2.8
CDS-10	10	4.4
CDS-12	12	6.3

2. The CDS Stormwater Treatment System can be used on-line or off-line.

3. A hydrodynamic separator, such as the CDS Stormwater Treatment System, cannot be used in series with another hydrodynamic separator to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

4. The maintenance plan for the sites using this device shall incorporate at a minimum, the maintenance requirements for the CDS Stormwater Treatment System shown attached.

In addition to the attached, the detailed maintenance plan must include all of the items identified in Chapter 8: Maintenance of the New Jersey Stormwater Best Management Manual. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel.

Additional information regarding the implementation of the Stormwater Management rules N.J.A.C. 7:8 are available at www.njstormwater.org. Please contact Sandra Blick of my office at (609) 633-7021 if you have any questions.

Sincerely,

James J. Murphy, Chief
Bureau of Nonpoint Pollution Control

c: Chron File
Richard Magee, NJCAT
Mark Pedersen, DLUR
Elizabeth Dragon, BNPC

CDS Maintenance

The CDS system must be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant deposition and transport may vary from year to year and regular inspections will help insure that the system is cleaned out at the appropriate time. At a minimum, inspections must be performed twice per year (i.e. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid pollutant accumulations, or in equipment washdown areas. Additionally, installations where excessive amounts of trash are expected should be inspected more frequently.

The visual inspection must ascertain that the system components are in working order and that there are no blockages or obstructions to the inlet and/or separation screen. The inspection must also identify accumulations of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick such as a stadia rod, tape measure or other measuring instrument. If sorbent material is used for enhanced removal of hydrocarbons then the level of discoloration of the sorbent material should also be identified during inspection. Sorbent material must be replaced when it is predominantly dark in color (similar to oil). It is useful and often required as part of a permit to keep a record of each inspection.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (screen/cylinder) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained behind the screen. For units possessing a sizable depth below grade (depth to pipe), a single access point allows for both sump cleanout and access behind the screen.

The CDS system must be cleaned when the level of sediment in the sump has reached a depth of 12 inches or more to avoid exceeding the maximum 24 inch sediment depth and/or when an appreciable level of hydrocarbons and trash has accumulated. If sorbent material is used, it must be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine if the height of the sediment pile off the bottom of the sump floor exceeds 75% (18 inches) of the total height of isolated sump.

Cleaning

Cleaning of the CDS systems should be done during dry weather conditions when no flow is entering the system. Cleanout of the CDS with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be pumped out if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis must be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually less expensive to dispose of than the oil/water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants. The screen should be power washed to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure proper safety precautions. Confined Space Entry procedures need to be followed.

Disposal of all material removed from the CDS system must be done is accordance with local regulations. In many locations, disposal of evacuated sediments may be handled in the same manner as disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

Illicit Discharge Compliance Statement

Responsibility:

The Owner is responsible for ultimate compliance with all provisions of the Massachusetts Stormwater Management Policy, the USEPA NPDES Construction General Permit and responsible for identifying and eliminating illicit discharges (as defined by the USEPA).

OWNER NAME: SLV School Street, LLC.

ADDRESS: 257 Hillside Avenue

Needham, MA 02494

TEL. NUMBER: (617) 276-7261

Engineer's Compliance Statement:

To the best of my knowledge, the attached plans, computations and specifications meet the requirements of Standard 10 of the Massachusetts Stormwater Handbook regarding illicit discharges to the stormwater management system and that no detectable illicit discharges exist on the site. All documents and attachments were prepared under my direction and qualified personnel properly gathered and evaluated the information submitted, to the best of my knowledge.

Included with this statement are site plans, drawn to scale, that identify the location of systems for conveying stormwater on the site and show that these systems do not allow the entry of any illicit discharges into the stormwater management system. The plans also show any systems for conveying wastewater and/or groundwater on the site and show that there are no connections between the stormwater and wastewater systems.

For a redevelopment project (if applicable), all actions taken to identify and remove illicit discharges, including without limitation, visual screening, dye or smoke testing, and the removal of any sources of illicit discharges to the stormwater management system are documented and included with this statement.

Notwithstanding the foregoing, an illicit discharge does not include discharges from the following activities or facilities: firefighting, water line flushing, landscape irrigation, uncontaminated groundwater, potable water sources, foundation drains, air conditioning condensation, footing drains, individual resident car washing, flows from riparian habitats and wetlands, dechlorinated water from swimming pools, water used for street washing, and water used to clean residential buildings without detergents.