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June 28, 2023

Stormwater Report

Randall Library Renovation and Addition
19 Crescent Street
Stow, MA 01775

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Land Surveying

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SECTION 1 Introduction

Nitsch Engineering has prepared this Stormwater Report to support the site plan review application to Town of Stow for the Randall Library Renovation and Addition located in Stow, MA. The Project site is located at 19 Crescent Street, Stow, MA (subsequently referred to as the “Site”). The Project includes a restoration or the original library building, removal of the existing addition and construction of a new building, landscaping, and stormwater management system.

The site improvements include the following:

1. Demolition of the existing addition;
2. Construction of a new addition;
3. Installation of new utilities to support the proposed building; and
4. Construction of a new stormwater management system.

The proposed stormwater management system has been designed to comply with the requirements of the Town of Stow Stormwater Management Policy and the Massachusetts Department of Environmental Protection (DEP) Stormwater Management Standards.

SECTION 2 Existing Conditions

The Site is located at 19 Crescent St, Stow, MA. The Site is currently developed on the corner of Crescent Street, Library Hill Road, and Common Road.

The site is approximately 0.14 acres including the existing building, parking areas, and associated walkways. The site is bounded by a residence to the east, the First Parish Unitarian Church to the southeast, Commons Road to the south, Library Hill Road to the west, and Crescent Street to the north.

Existing Drainage Infrastructure

Stormwater generated on the site at the existing Randall Library flows overland to the adjacent streets stormwater infrastructure and the stormwater from the concrete entrance is collected via area drain. Stormwater from the roof is collected via downspouts that flow overland off-site. There are no known stormwater management systems on site.

NRSC Soil Designations

Based on the Natural Resources Conservation Service (NRCS) Middlesex County Soil Survey, Issued February 2010, the site of the Randall Library property is classified as Merrimac-Urban land complex with 0 to 8 percent slopes. Merrimac-Urban land complex typically consists of fine sandy loam and gravelly sandy loam and is described as somewhat excessively drained. Depth to water table is more than 80 inches.

The NRCS classifies the Merrimac-Urban land complex as Hydrologic Soil Group (HSG) 'A'. NRCS describes the soil group 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.

Table 1. NRCS Soil Classification Summary

Soil Unit	Soil Series	Hydrologic Soil Group
626B	Merrimac-Urban Land Complex, 0 to 8 percent slopes	A

Onsite Soil Investigations

A subsurface investigation consisting of three soil borings was conducted by Geotechnical Consultants, Inc. in February 2023. The general subsurface conditions include fill over sand and gravel with groundwater approximately 9-10.5 feet below grade. The geotechnical report can be found in Appendix C, Supplemental Information.

Total Maximum Daily Load (TMDL)

The Site ultimately discharges into the Assabet River and therefore is also subject to the Total Maximum Daily Load (TMDL) for the SuAsCo watershed which includes a 90% phosphorus reduction. The site BMPs will be designed to remove the required nutrient levels. These calculations will be provided as design progresses.

SECTION 3 Proposed Conditions

Project Description

The Project includes a restoration of the original library building, removal of the existing addition and construction of a new building, landscaping, and stormwater management system. The proposed site improvements include the following:

1. Demolition of the existing addition;
2. Construction of a new addition;
3. Installation of new utilities to support the proposed building; and
4. Construction of a new stormwater management system.

State if the project is considered a new development. The Project is anticipated to increase the overall impervious area for the Project by approximately 0.012 acres. Refer to Table 2 for a comparison of the existing and proposed land use for the Site.

Table 2. Proposed land use for 19 Crescent St, Stow, MA (in acres)

Land Use	Existing Site (acres)	Proposed Site (acres)	Change
Buildings	0.115	0.114	-0.001
Site Pavement	0.067	0.079	+0.013
Landscaped Areas	0.165	0.154	-0.012
Undeveloped Areas	0.000	0.000	0.000
Total	0.347	0.347	---

Stormwater Management System

The Site will include the installation of a stormwater management system that is being designed to meet the MassDEP Stormwater Management Standards and the Town of Stow Stormwater Management Standards. As a new development, the Project is required to provide peak flow and volume mitigation under the MassDEP Regulations and provide water quality treatment and groundwater recharge.

The proposed stormwater management system for the Project will include deep sump and hooded catch basins, subsurface infiltration systems, and proprietary water quality structures. Overflow from the proposed BMPs will be discharged to the system i using stormwater outfalls with level spreaders to minimize concentrated flow.

Deep Sump and Hooded Catch Basins

Deep sump and hooded catch basins are proposed to provide pretreatment in the impervious areas of the parking lot and driveways. Stormwater captured in the catch basins will be directed to another treatment or infiltration BMP prior to discharge.

Subsurface Infiltration/Detention Systems

Stormwater will be collected and infiltrated using one subsurface infiltration system. The Subsurface Infiltration System is proposed to collect and infiltrate runoff from the proposed building and immediately adjacent impervious and landscaped site area. The system consists of an 18" pipe system enveloped by crushed stone. The Subsurface Infiltration System is designed to reduce the peak rate in the 2-, 10-, 25- and 100-year design storms.

Water Quality Structures

One proprietary water quality structures are proposed for water quality pretreatment in areas of the Site where space is limited or additional pretreatment is required prior to infiltration. These BMPs have been designed to remove greater than 80% TSS in conjunction with their associated deep sump and hooded catch basins. Sizing calculations will be provided as design continues.

Stormwater Management During Construction

The Site Contractor will be responsible for stormwater management of the active construction site. Erosion and sediment controls will include at a minimum perimeter erosion control of silt fence and straw wattles and stormwater inlet protection.

SECTION 4 Stormwater Management Analysis

Methodology

Nitsch Engineering completed a hydrologic analysis of the existing project site utilizing Soil Conservation Service (SCS) Runoff Curve Number (CN) methodology. The SCS method calculates the rate at which the runoff reaches the design point considering several factors: the slope and flow lengths of the subcatchment area, the soil type of the subcatchment area, and the type of surface cover in the subcatchment area. HydroCAD Version 10.00 computer modeling software was used in conjunction with the SCS method to determine the peak runoff rates and runoff volumes for the 2-, 10-, 25-, and 100-year, 24-hour storm events. The proposed project site is being analyzed with the same methodology.

The Site was divided into multiple drainage areas, or subcatchments, which drain to the design points along the property boundary and within the site. For each subcatchment area, SCS Runoff Curve Numbers (CNs) were selected by using the cover type and hydrologic soil group of each area. The peak runoff rates and runoff volumes for the 2-, 10-, 25- and 100-year 24-hour storm events were then determined by inputting the drainage areas, CNs, and time of concentration (T_c) paths into the HydroCAD model.

The National Oceanic and Atmospheric Administration Atlas 14 precipitation frequency estimates were used to calculate the 2-, 10-, 25-, and 100- year 24-hour storm events in HydroCAD. Refer to the HydroCAD calculations in Appendix A and B for rainfall information.

HydroCAD Version 10.00

The HydroCAD computer program uses SCS and TR-20 methods to model drainage systems. TR-20 (Technical Release 20) was developed by the Soil Conservation Service to estimate runoff and peak discharges in small watersheds. TR-20 is generally accepted by engineers and reviewing authorities as the standard method for estimating runoff and peak discharges.

HydroCAD Version 10.00 uses up to four types of components to analyze the hydrology of a given site: subcatchments, reaches, basins, and links. Subcatchments are areas of land that produce surface runoff. The area, weighted CN, and T_c characterize each individual subcatchment area. Reaches are generally uniform streams, channels, or pipes that convey water from one point to another. A basin is any impoundment that fills with water from one or more sources and empties via an outlet structure. Links are used to introduce hydrographs into a project from another source or to provide a junction for more than one hydrograph within a project. The time span for the model was set for 0-48 hours in order to prevent truncation of the hydrograph.

Existing Hydrologic Conditions

As summarized in Section 2.1, Nitsch Engineering delineated the project site into one on-site subcatchment (watershed) areas discharging to one design points utilizing an existing conditions survey and on-site observations. The HydroCAD model for existing conditions is provided in Appendix A and results from the HydroCAD calculations are summarized below in Table 3.

Proposed Hydrologic Conditions

The proposed project has been designed to mitigate the change in stormwater runoff at each of the design points as required by the DEP Stormwater Management Standards and the Town of Stow Stormwater Management Standards. The existing watershed areas were modified to reflect the proposed topography, storm drainage structures and BMPs, and roof areas. The HydroCAD model for proposed conditions is provided in Appendix B and results from the calculations are summarized in Table 3.

Peak Flow Rates

The proposed stormwater management system is expected to reduce the proposed peak runoff rates to at or below the existing rates for the Design Point. Table 3 below summarize the existing and proposed hydrologic analyses for the site at each design point.

Table 3. Peak Rates of Runoff in Cubic Feet per Second (cfs)

	Storm Event	2-year	10-year	25-year	100-year
DP	Existing	0.45	1.01	1.39	1.99
	Proposed	0.39	1.00	1.37	1.98

Annual Load Reduction of Phosphorus (90%) and TSS (80%)

The proposed stormwater management system will be designed to remove greater than 80% of the average annual post-construction load of Total Suspended Solids (TSS). Structural stormwater BMPs including deep sump and hooded catch basins, Stormtech subsurface infiltration basins, and Stormceptor® water quality units will be sized to capture the required water quality volume (1 inch over the project site) and remove a minimum of 80% of total suspended solids.

SECTION 5 MassDEP Stormwater Management Standards

The Project is considered a ***new development*** under the DEP Stormwater Management System. The Site will be designed to meet and exceed the MassDEP Stormwater Management Standards as summarized below:

Standard 1: No New Untreated Discharges

The Project will not discharge any untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth. Stormwater from the Site will be collected and treated in accordance with the MassDEP Stormwater Management Standards and stormwater outfalls will be stabilized to prevent erosion.

Standard 2: Peak Rate Attenuation

The proposed stormwater management system will be designed so that the post-development peak discharge rates do not exceed pre-development peak discharge rates. To prevent storm damage and downstream flooding, the proposed stormwater management practices will mitigate peak runoff rates for the 2-, 10-, 25- and 100-year, 24 hour storm events. Refer to Table 3 for a pre- and post- development peak runoff rate comparison.

Standard 3: Groundwater Recharge

The Site was designed using environmentally-sensitive site design, low impact development techniques, and stormwater BMP treatment trains to minimize the loss of annual recharge to groundwater. The annual recharge from the post-development site will approximate the annual recharge from pre-development conditions based on soil type using the guidelines provided in the MassDEP Stormwater Management Handbook.

Impervious Area in HSG A = 3,451 square feet
Rv (Recharge Volume) = 3,451 x 0.6 in. / (12 inches/ft)
= 173 cubic feet

Total Required Recharge Volume = 173 cubic feet

The infiltration BMPs are sized to exceed the recharge volume required under the MassDEP Stormwater Management Standards (Table 5)

Table 5. Proposed Recharge Volumes for Stormwater BMPs

Infiltration BMP	Recharge Volume (cf)
Subsurface Infiltration System	216
Total	**216**

A minimum 4 feet of separation will be maintained between the bottom of the infiltration system and seasonal high groundwater.

Standard 4: Water Quality Treatment

The proposed stormwater management system will be designed to remove greater than 80% of the average annual post-construction load of Total Suspended Solids (TSS). Structural stormwater BMPs including deep sump and hooded catch basins, Stormtech subsurface infiltration basins, and Stormceptor® water quality units will be sized to capture the required water quality volume (1 inch over the project site) and remove a minimum of

80% of total suspended solids.

Table 6. Proposed Treatment Train Summary

Watershed	Treatment Train
DA	Area Drain – Subsurface Infiltration
DA	Catch Basin – Water Quality Structure – Subsurface Infiltration

Standard 5: Land Uses with Higher Potential Pollutant Loads

The project is not considered a LUHPPL and therefore, this standard is not applicable.

Standard 6: Critical Areas

The Project is not located within any critical areas. Therefore, this standard is not applicable.

Standard 7: Redevelopments

The Project is not considered a redevelopment under the MassDEP Stormwater Management Standards. Therefore, this standard is not applicable.

Standard 8: Construction Period Pollution Prevention and Sedimentation Control

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) will be developed and implemented during the design process.

Standard 9: Operation and Maintenance Plan

A post-construction operation and maintenance plan will be prepared and will be implemented to ensure that stormwater management systems function as designed. Source control and stormwater BMP operation requirements for the site are summarized in the Long-Term Pollution Prevention Plan and Operation and Maintenance Plan will be provided at a later date.

Standard 10: Prohibition of Illicit Discharges

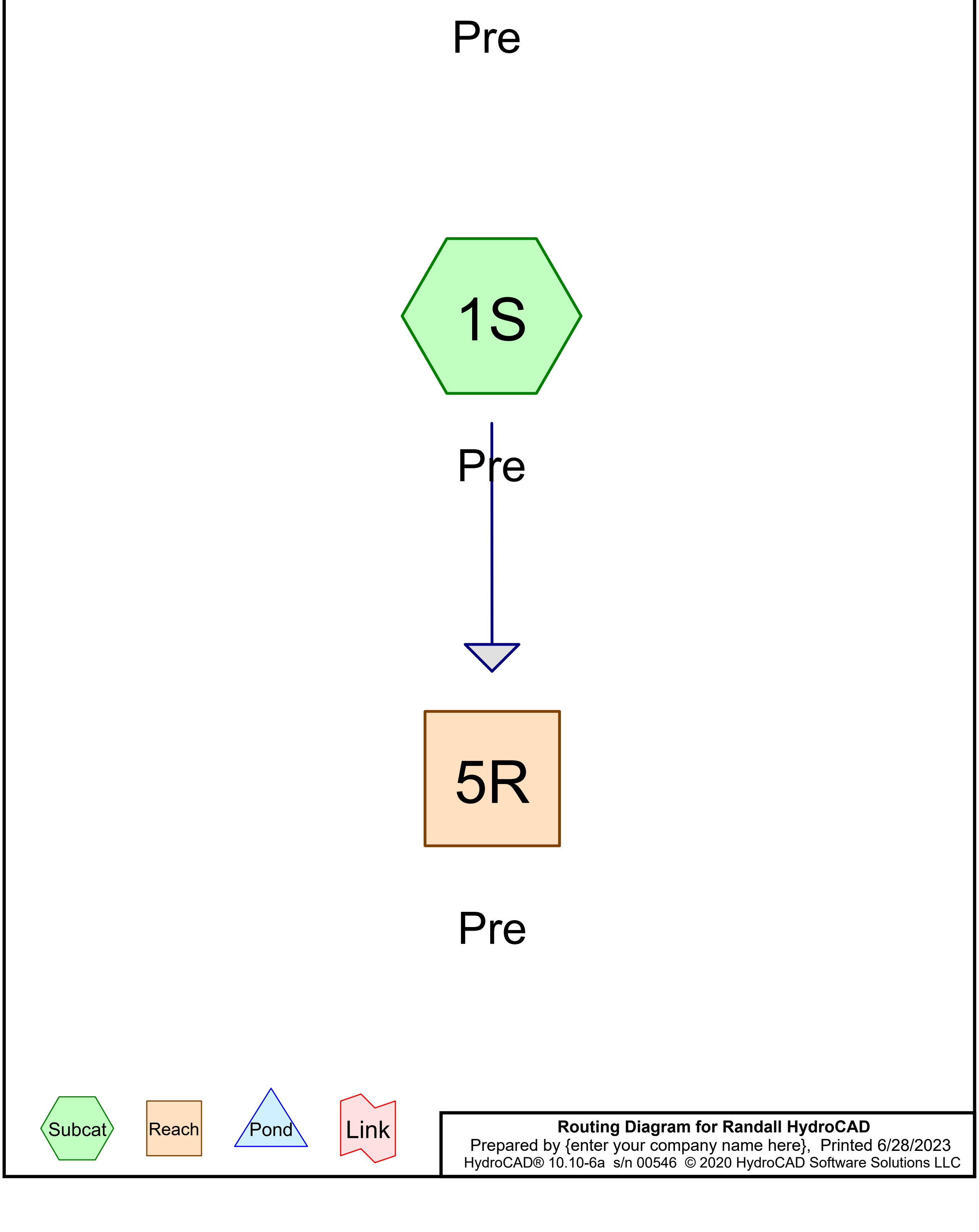
There will be no illicit discharges to the stormwater management system associated with the Project. An Illicit Discharge Compliance Statement will be provided prior to construction.

SECTION 6 Conclusion

In conclusion, the Project’s stormwater management system will reduce or maintain peak runoff rates and volumes through the widespread use of infiltration BMPs and improve the water quality of stormwater being discharged from the Site. The Project is being designed to meet and exceed the MassDEP Stormwater Management Standards and the Town of Stow Stormwater Management Standards.

APPENDIX A

Existing Conditions – HydroCAD Calculations



Routing Diagram for Randall HydroCAD
Prepared by {enter your company name here}, Printed 6/28/2023
HydroCAD® 10.10-6a s/n 00546 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-year	Type III 24-hr		Default	24.00	1	3.27	2
2	10-year	Type III 24-hr		Default	24.00	1	5.05	2
3	25-year	Type III 24-hr		Default	24.00	1	6.15	2
4	100-year	Type III 24-hr		Default	24.00	1	7.86	2

Area Listing (selected nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
7,202	49	50-75% Grass cover, Fair, HSG A (1S)
2,889	98	Paved parking, HSG A (1S)
5,021	98	Roofs, HSG A (1S)
15,112	**75**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
15,112	HSG A	1S
0	HSG B	
0	HSG C	
0	HSG D	
0	Other	
15,112		**TOTAL AREA**

Ground Covers (selected 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	Su Nu
7,202	0	0	0	0	7,202	50-75% Grass cover, Fair	
2,889	0	0	0	0	2,889	Paved parking	
5,021	0	0	0	0	5,021	Roofs	
15,112	**0**	**0**	**0**	**0**	**15,112**	**TOTAL AREA**	

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Pre Runoff Area=15,112 sf 52.34% Impervious Runoff Depth>1.14"
Tc=6.0 min CN=75 Runoff=0.45 cfs 1,436 cf

Reach 5R: Pre Inflow=0.45 cfs 1,436 cf
Outflow=0.45 cfs 1,436 cf

Total Runoff Area = 15,112 sf Runoff Volume = 1,436 cf Average Runoff Depth = 1.14"
47.66% Pervious = 7,202 sf 52.34% Impervious = 7,910 sf

Summary for Subcatchment 1S: Pre

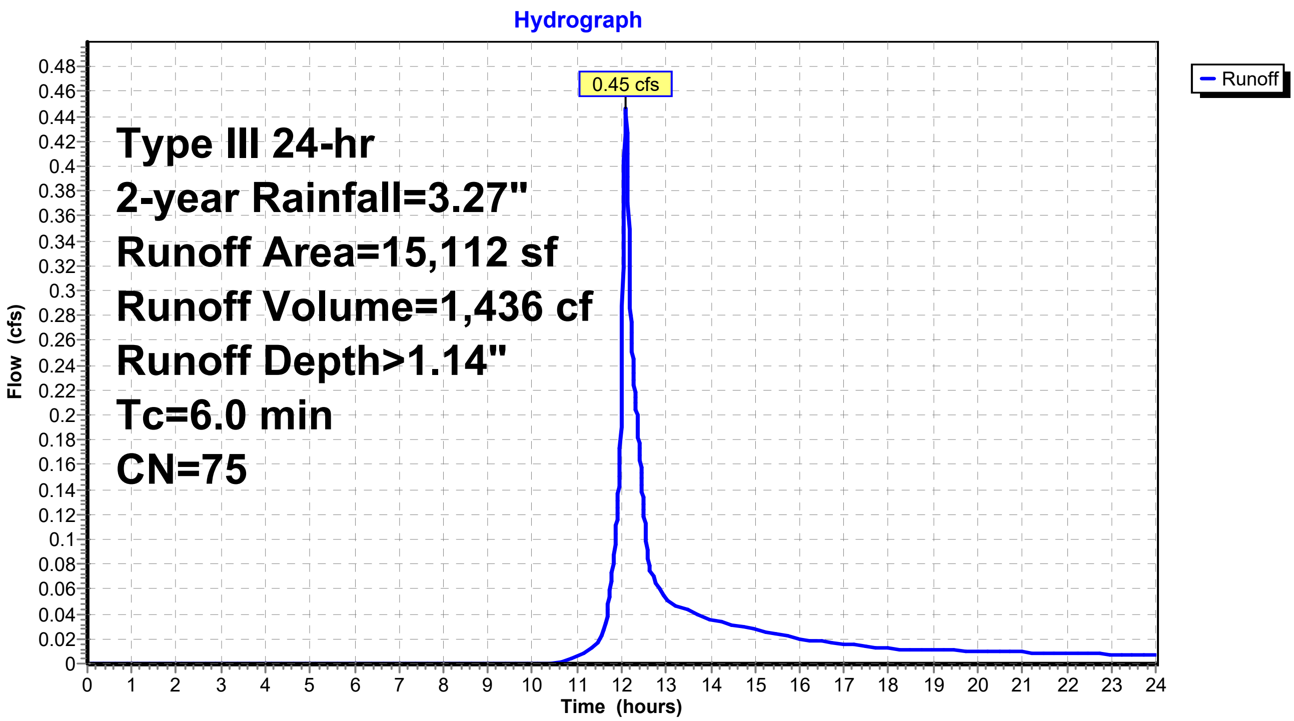
Runoff = 0.45 cfs @ 12.09 hrs, Volume= 1,436 cf, Depth> 1.14"
Routed to Reach 5R : Pre

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-year Rainfall=3.27"

Area (sf)	CN	Description
5,021	98	Roofs, HSG A
2,889	98	Paved parking, HSG A
7,202	49	50-75% Grass cover, Fair, HSG A
15,112	75	Weighted Average
7,202		47.66% Pervious Area
7,910		52.34% Impervious Area

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

Subcatchment 1S: Pre

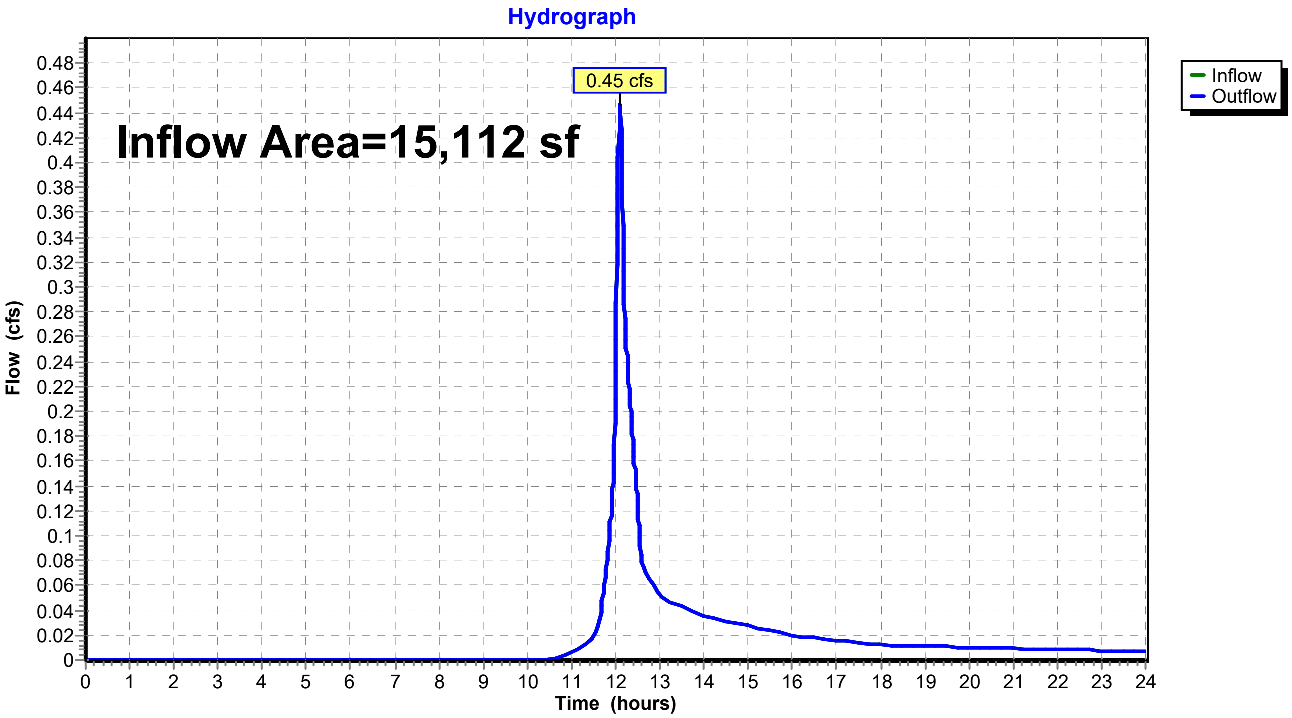


Summary for Reach 5R: Pre

Inflow Area =	15,112 sf, 52.34% Impervious,	Inflow Depth > 1.14"	for 2-year event
Inflow =	0.45 cfs @ 12.09 hrs, Volume=	1,436 cf	
Outflow =	0.45 cfs @ 12.09 hrs, Volume=	1,436 cf, Atten= 0%, Lag= 0.0 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Reach 5R: Pre



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Pre Runoff Area=15,112 sf 52.34% Impervious Runoff Depth>2.49"
Tc=6.0 min CN=75 Runoff=1.01 cfs 3,132 cf

Reach 5R: Pre Inflow=1.01 cfs 3,132 cf
Outflow=1.01 cfs 3,132 cf

Total Runoff Area = 15,112 sf Runoff Volume = 3,132 cf Average Runoff Depth = 2.49"
47.66% Pervious = 7,202 sf 52.34% Impervious = 7,910 sf

Summary for Subcatchment 1S: Pre

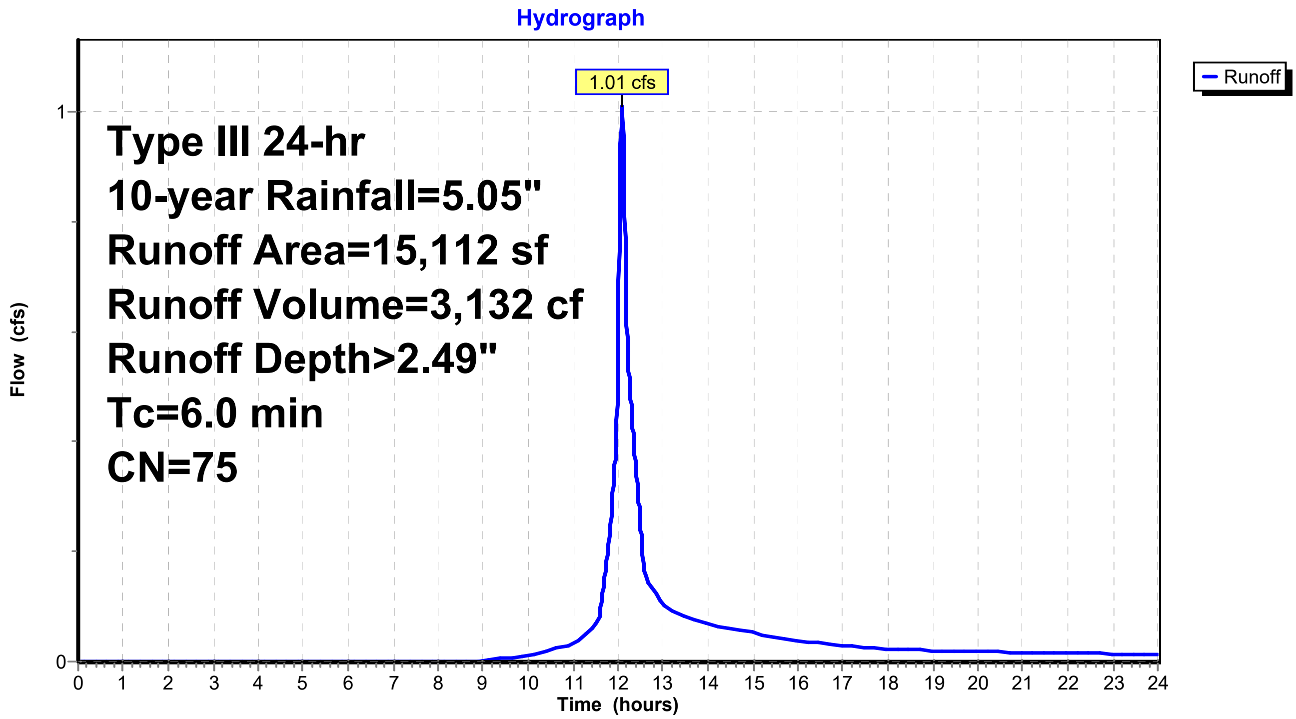
Runoff = 1.01 cfs @ 12.09 hrs, Volume= 3,132 cf, Depth> 2.49"
Routed to Reach 5R : Pre

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-year Rainfall=5.05"

Area (sf)	CN	Description
5,021	98	Roofs, HSG A
2,889	98	Paved parking, HSG A
7,202	49	50-75% Grass cover, Fair, HSG A
15,112	75	Weighted Average
7,202		47.66% Pervious Area
7,910		52.34% Impervious Area

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

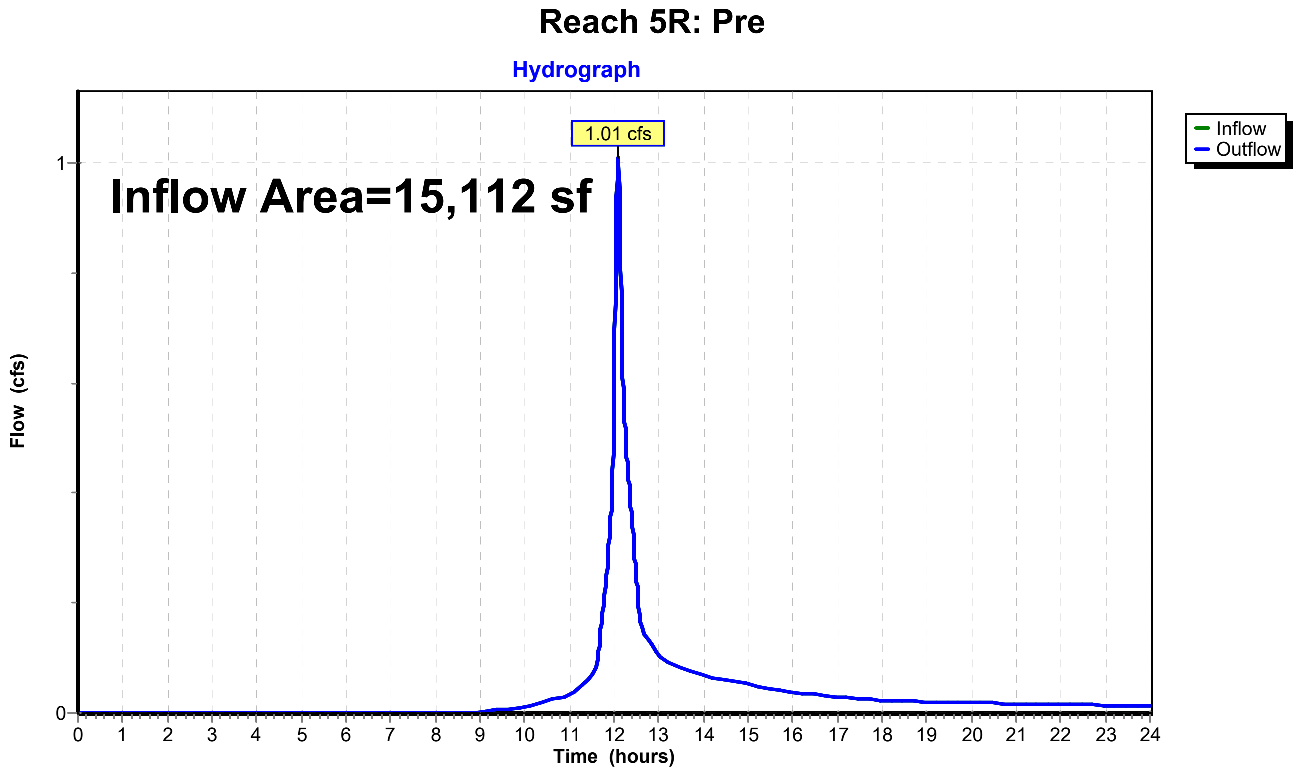
Subcatchment 1S: Pre



Summary for Reach 5R: Pre

Inflow Area = 15,112 sf, 52.34% Impervious, Inflow Depth > 2.49" for 10-year event
Inflow = 1.01 cfs @ 12.09 hrs, Volume= 3,132 cf
Outflow = 1.01 cfs @ 12.09 hrs, Volume= 3,132 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Pre Runoff Area=15,112 sf 52.34% Impervious Runoff Depth>3.41"
Tc=6.0 min CN=75 Runoff=1.39 cfs 4,290 cf

Reach 5R: Pre Inflow=1.39 cfs 4,290 cf
Outflow=1.39 cfs 4,290 cf

Total Runoff Area = 15,112 sf Runoff Volume = 4,290 cf Average Runoff Depth = 3.41"
47.66% Pervious = 7,202 sf 52.34% Impervious = 7,910 sf

Summary for Subcatchment 1S: Pre

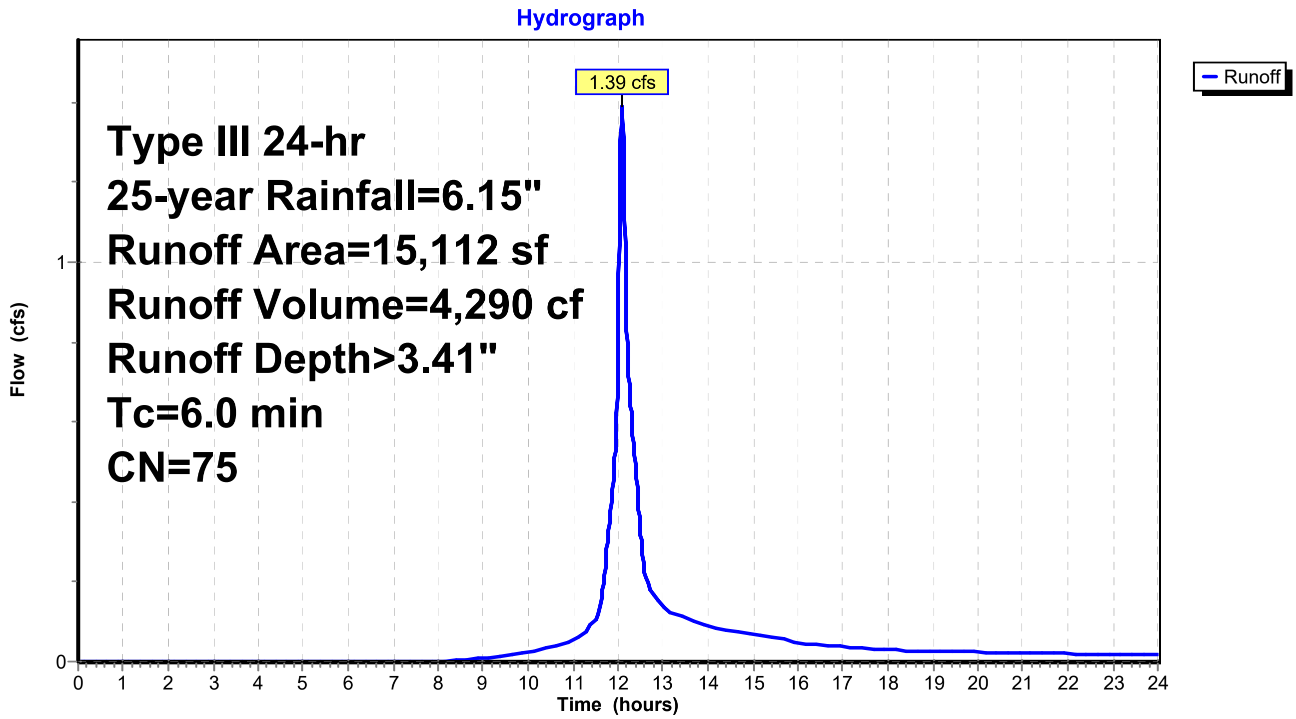
Runoff = 1.39 cfs @ 12.09 hrs, Volume= 4,290 cf, Depth> 3.41"
Routed to Reach 5R : Pre

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-year Rainfall=6.15"

Area (sf)	CN	Description
5,021	98	Roofs, HSG A
2,889	98	Paved parking, HSG A
7,202	49	50-75% Grass cover, Fair, HSG A
15,112	75	Weighted Average
7,202		47.66% Pervious Area
7,910		52.34% Impervious Area

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

Subcatchment 1S: Pre

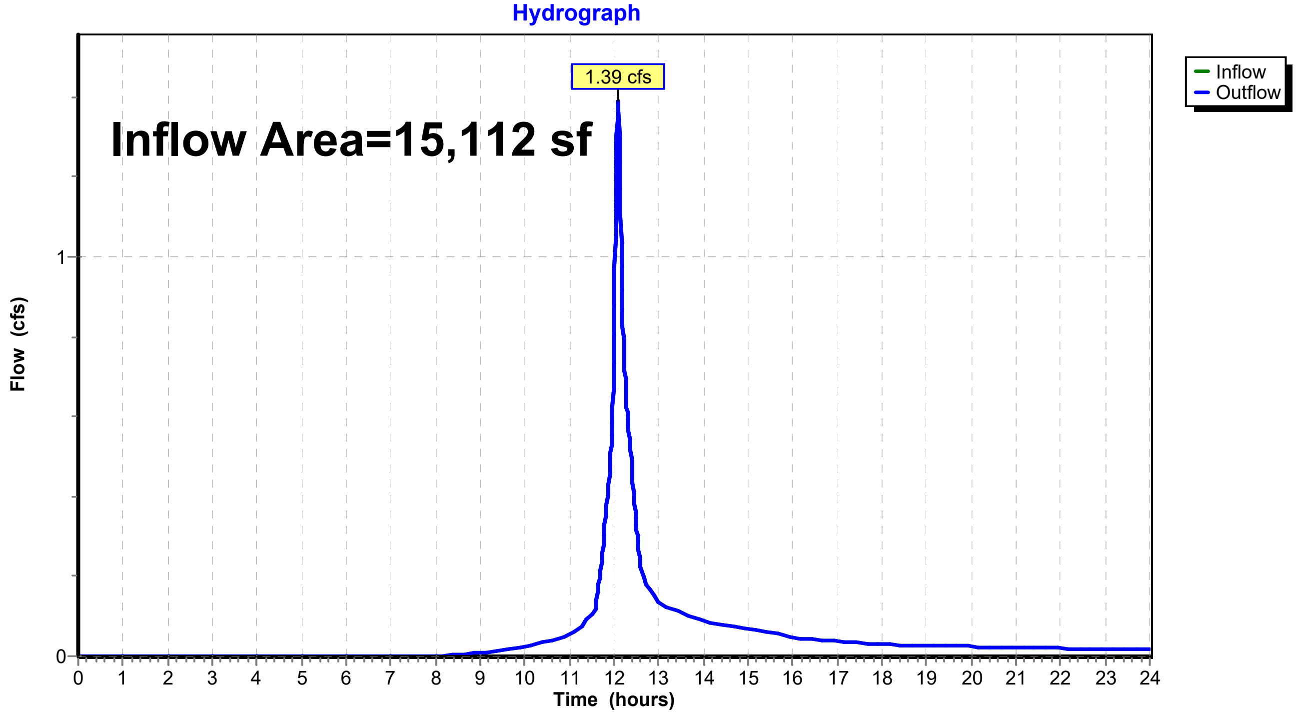


Summary for Reach 5R: Pre

Inflow Area = 15,112 sf, 52.34% Impervious, Inflow Depth > 3.41" for 25-year event
Inflow = 1.39 cfs @ 12.09 hrs, Volume= 4,290 cf
Outflow = 1.39 cfs @ 12.09 hrs, Volume= 4,290 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Reach 5R: Pre



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Pre Runoff Area=15,112 sf 52.34% Impervious Runoff Depth>4.91"
Tc=6.0 min CN=75 Runoff=1.99 cfs 6,184 cf

Reach 5R: Pre Inflow=1.99 cfs 6,184 cf
Outflow=1.99 cfs 6,184 cf

Total Runoff Area = 15,112 sf Runoff Volume = 6,184 cf Average Runoff Depth = 4.91"
47.66% Pervious = 7,202 sf 52.34% Impervious = 7,910 sf

Summary for Subcatchment 1S: Pre

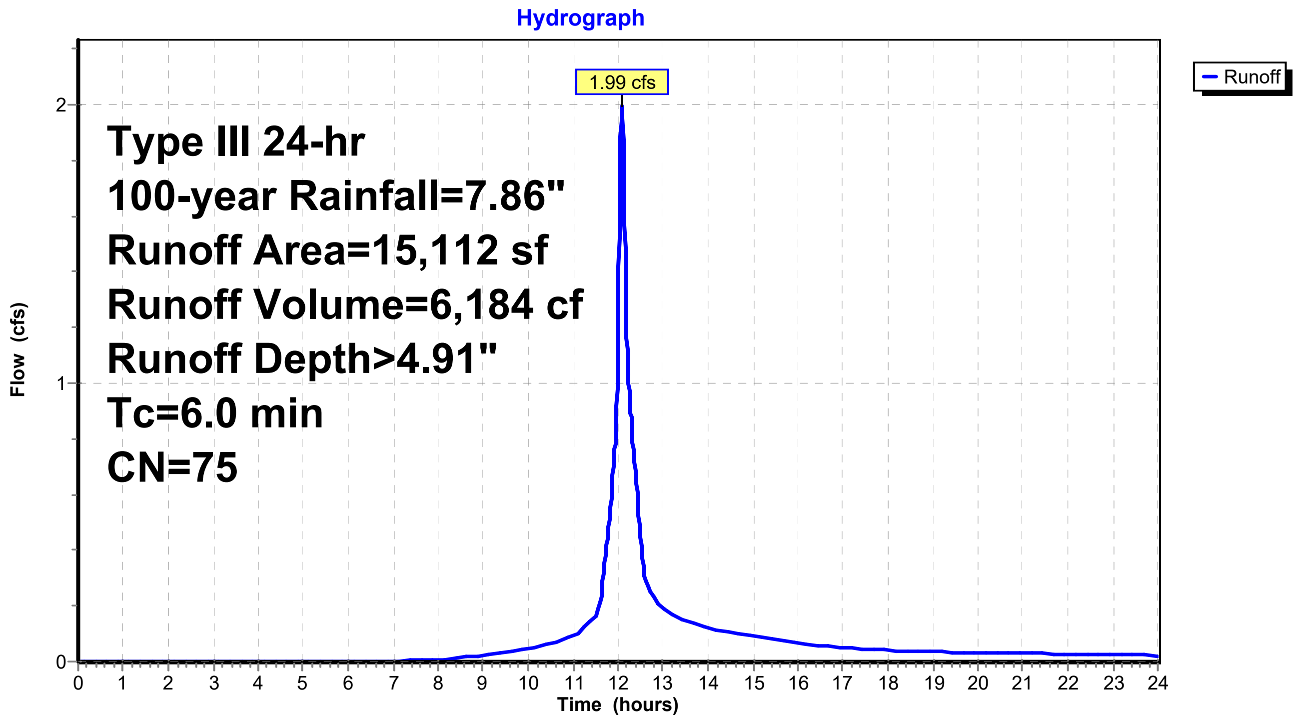
Runoff = 1.99 cfs @ 12.09 hrs, Volume= 6,184 cf, Depth> 4.91"
Routed to Reach 5R : Pre

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-year Rainfall=7.86"

Area (sf)	CN	Description
5,021	98	Roofs, HSG A
2,889	98	Paved parking, HSG A
7,202	49	50-75% Grass cover, Fair, HSG A
15,112	75	Weighted Average
7,202		47.66% Pervious Area
7,910		52.34% Impervious Area

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

Subcatchment 1S: Pre

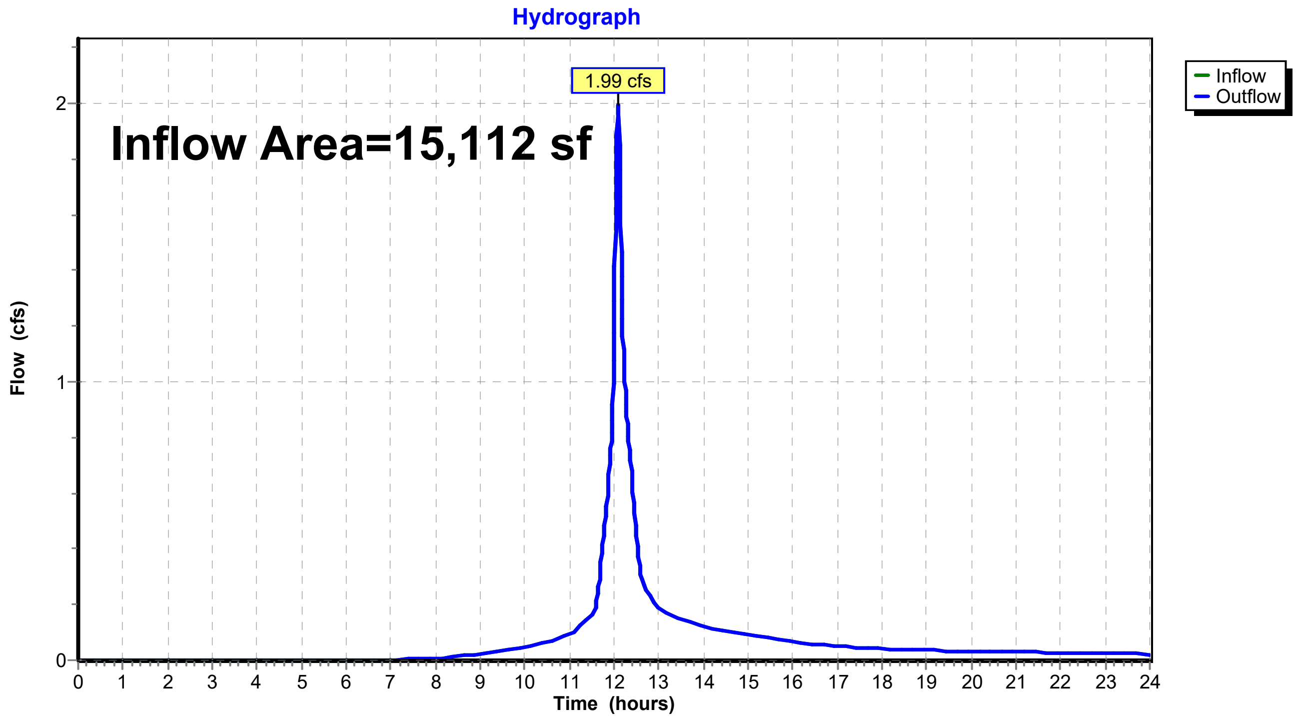


Summary for Reach 5R: Pre

Inflow Area = 15,112 sf, 52.34% Impervious, Inflow Depth > 4.91" for 100-year event
Inflow = 1.99 cfs @ 12.09 hrs, Volume= 6,184 cf
Outflow = 1.99 cfs @ 12.09 hrs, Volume= 6,184 cf, Atten= 0%, Lag= 0.0 min

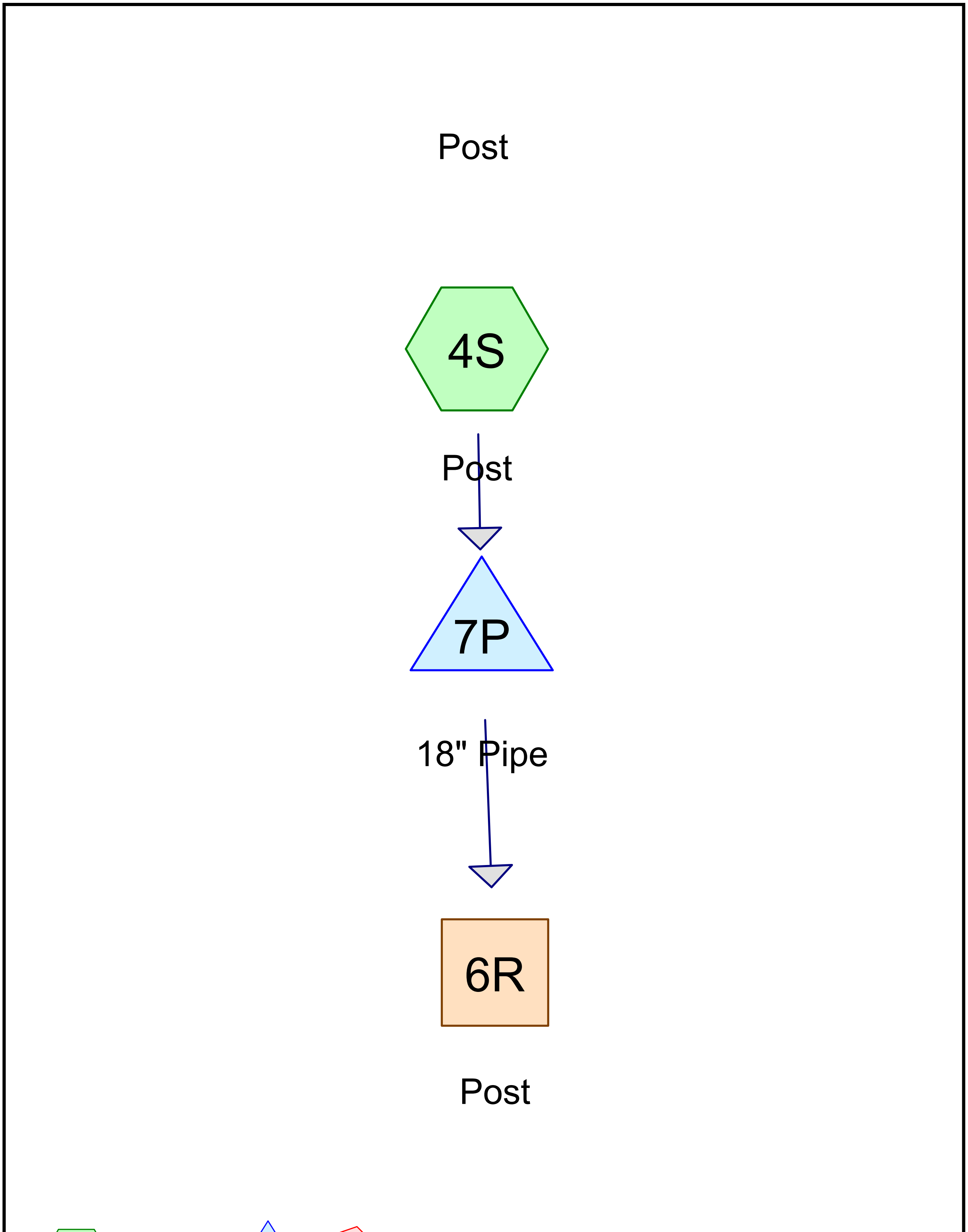
Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Reach 5R: Pre



APPENDIX B

Proposed Conditions – HydroCAD Calculations



Routing Diagram for Randall HydroCAD
Prepared by {enter your company name here}, Printed 6/28/2023
HydroCAD® 10.10-6a s/n 00546 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-year	Type III 24-hr		Default	24.00	1	3.27	2
2	10-year	Type III 24-hr		Default	24.00	1	5.05	2
3	25-year	Type III 24-hr		Default	24.00	1	6.15	2
4	100-year	Type III 24-hr		Default	24.00	1	7.86	2

Area Listing (selected nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
6,694	49	50-75% Grass cover, Fair, HSG A (4S)
3,452	98	Paved parking, HSG A (4S)
4,966	98	Roofs, HSG A (4S)
15,112	**76**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
15,112	HSG A	4S
0	HSG B	
0	HSG C	
0	HSG D	
0	Other	
15,112		**TOTAL AREA**

Ground Covers (selected 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	Su Nu
6,694	0	0	0	0	6,694	50-75% Grass cover, Fair	
3,452	0	0	0	0	3,452	Paved parking	
4,966	0	0	0	0	4,966	Roofs	
15,112	**0**	**0**	**0**	**0**	**15,112**	**TOTAL AREA**	

Pipe Listing (selected nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)
1	7P	17.55	17.45	7.5	0.0133	0.012	0.0	12.0	0.0

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment4S: Post Runoff Area=15,112 sf 55.70% Impervious Runoff Depth>1.20"
Tc=6.0 min CN=76 Runoff=0.47 cfs 1,510 cf

Reach 6R: Post Inflow=0.39 cfs 617 cf
Outflow=0.39 cfs 617 cf

Pond 7P: 18" Pipe Peak Elev=17.91' Storage=270 cf Inflow=0.47 cfs 1,510 cf
Discarded=0.02 cfs 842 cf Primary=0.39 cfs 617 cf Outflow=0.41 cfs 1,459 cf

Total Runoff Area = 15,112 sf Runoff Volume = 1,510 cf Average Runoff Depth = 1.20"
44.30% Pervious = 6,694 sf 55.70% Impervious = 8,418 sf

Summary for Subcatchment 4S: Post

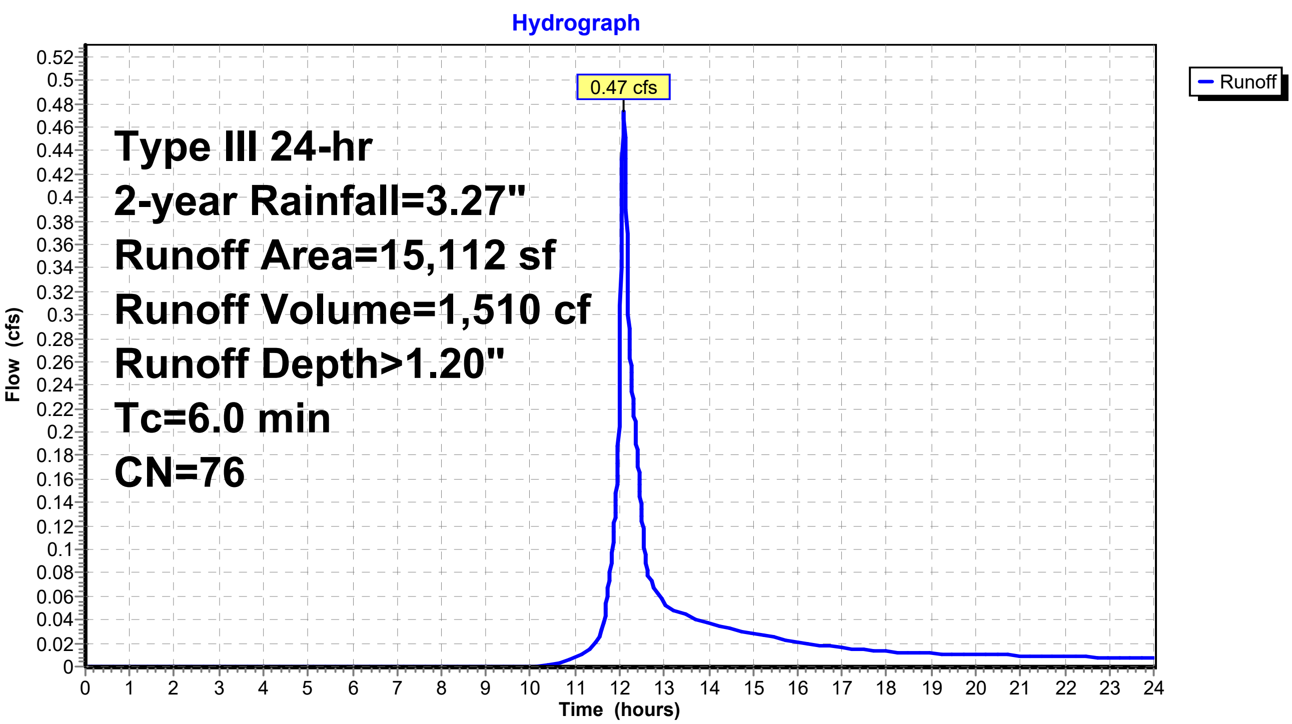
Runoff = 0.47 cfs @ 12.09 hrs, Volume= 1,510 cf, Depth> 1.20"
Routed to Pond 7P : 18" Pipe

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-year Rainfall=3.27"

Area (sf)	CN	Description
4,966	98	Roofs, HSG A
3,452	98	Paved parking, HSG A
6,694	49	50-75% Grass cover, Fair, HSG A
15,112	76	Weighted Average
6,694		44.30% Pervious Area
8,418		55.70% Impervious Area

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

Subcatchment 4S: Post

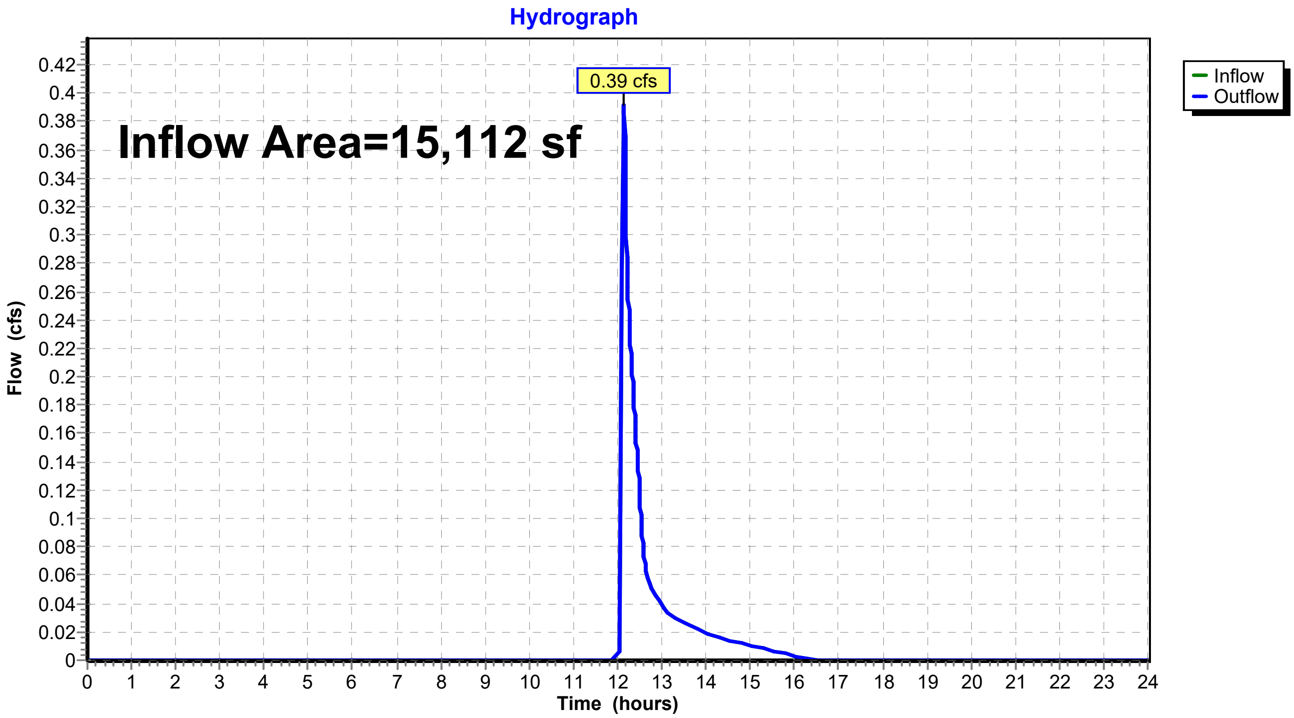


Summary for Reach 6R: Post

Inflow Area = 15,112 sf, 55.70% Impervious, Inflow Depth = 0.49" for 2-year event
Inflow = 0.39 cfs @ 12.14 hrs, Volume= 617 cf
Outflow = 0.39 cfs @ 12.14 hrs, Volume= 617 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Reach 6R: Post



Summary for Pond 7P: 18" Pipe

Inflow Area = 15,112 sf, 55.70% Impervious, Inflow Depth > 1.20" for 2-year event
Inflow = 0.47 cfs @ 12.09 hrs, Volume= 1,510 cf
Outflow = 0.41 cfs @ 12.14 hrs, Volume= 1,459 cf, Atten= 13%, Lag= 2.9 min
Discarded = 0.02 cfs @ 11.46 hrs, Volume= 842 cf
Primary = 0.39 cfs @ 12.14 hrs, Volume= 617 cf
Routed to Reach 6R : Post

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 17.91' @ 12.14 hrs Surf.Area= 323 sf Storage= 270 cf

Plug-Flow detention time= 97.5 min calculated for 1,459 cf (97% of inflow)
Center-of-Mass det. time= 78.9 min (932.4 - 853.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	16.00'	271 cf	**15.02'W x 21.50'L x 3.08'H Field A**
			996 cf Overall - 223 cf Embedded = 773 cf x 35.0% Voids
#2A	17.00'	180 cf	**ADS N-12 18"** x 5 Inside #1
			Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf
			Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf
			5 Chambers in 5 Rows
		451 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	16.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	17.55'	**12.0" Round Culvert**
			L= 7.5' CPP, projecting, no headwall, Ke= 0.900
			Inlet / Outlet Invert= 17.55' / 17.45' S= 0.0133 '/' Cc= 0.900
			n= 0.012 Corrugated PP, smooth interior, Flow Area= 0.79 sf
#3	Device 2	17.80'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 11.46 hrs HW=16.03' (Free Discharge)
↑**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.39 cfs @ 12.14 hrs HW=17.91' (Free Discharge)
↑**2=Culvert** (Barrel Controls 0.39 cfs @ 2.31 fps)
↑**3=Sharp-Crested Rectangular Weir** (Passes 0.39 cfs of 0.45 cfs potential flow)

Pond 7P: 18" Pipe - Chamber Wizard Field A

Chamber Model = ADS N-12 18" (ADS N-12® Pipe)
Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf
Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf

21.0" Wide + 14.3" Spacing = 35.3" C-C Row Spacing

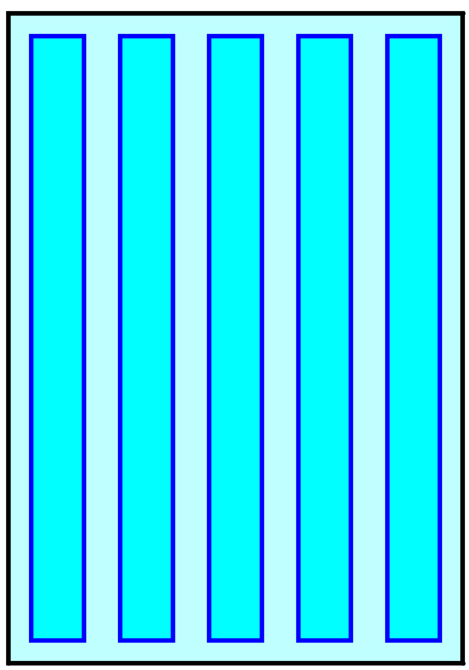
1 Chambers/Row x 20.00' Long = 20.00' Row Length +9.0" End Stone x 2 = 21.50' Base Length
5 Rows x 21.0" Wide + 14.3" Spacing x 4 + 9.0" Side Stone x 2 = 15.02' Base Width
12.0" Stone Base + 21.0" Chamber Height + 4.0" Stone Cover = 3.08' Field Height

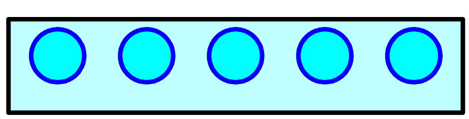
5 Chambers x 36.0 cf = 180.0 cf Chamber Storage
5 Chambers x 44.5 cf = 222.6 cf Displacement

995.8 cf Field - 222.6 cf Chambers = 773.2 cf Stone x 35.0% Voids = 270.6 cf Stone Storage

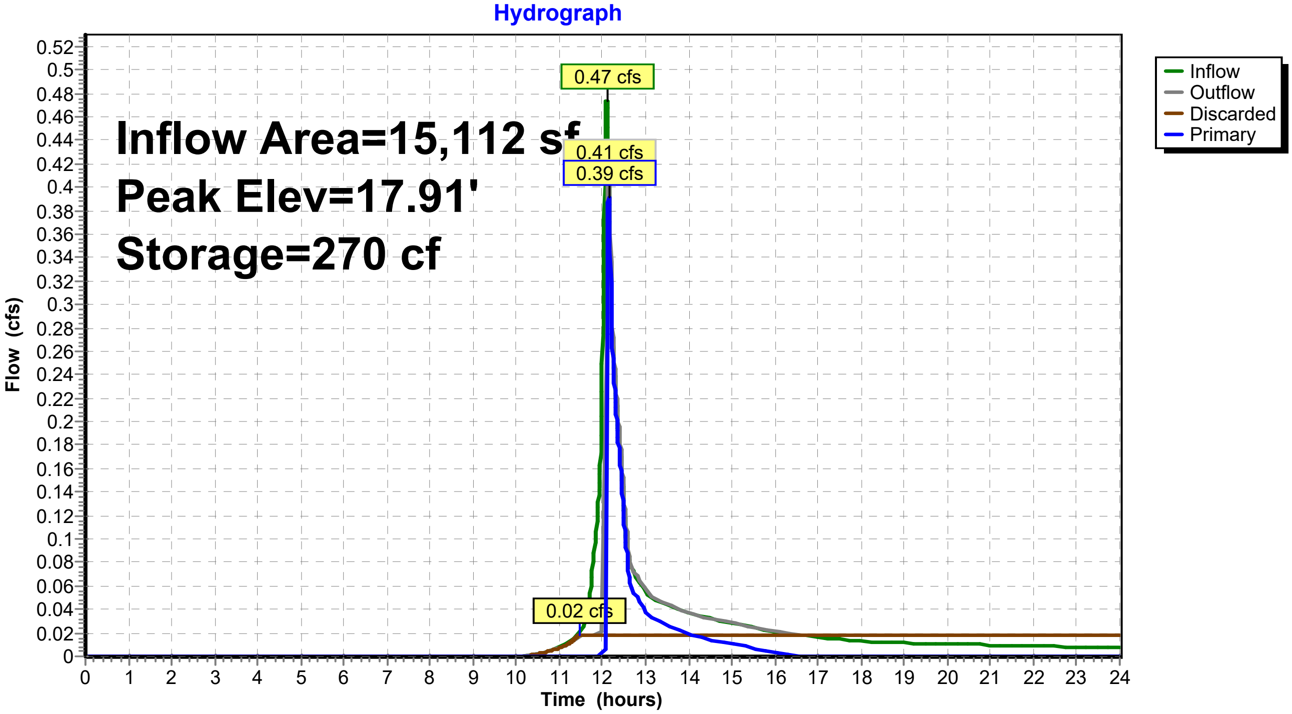
Chamber Storage + Stone Storage = 450.6 cf = 0.010 af
Overall Storage Efficiency = 45.3%
Overall System Size = 21.50' x 15.02' x 3.08'

5 Chambers
36.9 cy Field
28.6 cy Stone





Pond 7P: 18" Pipe



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment4S: Post Runoff Area=15,112 sf 55.70% Impervious Runoff Depth>2.57"
Tc=6.0 min CN=76 Runoff=1.05 cfs 3,241 cf

Reach 6R: Post Inflow=1.00 cfs 2,091 cf
Outflow=1.00 cfs 2,091 cf

Pond 7P: 18" Pipe Peak Elev=18.17' Storage=323 cf Inflow=1.05 cfs 3,241 cf
Discarded=0.02 cfs 936 cf Primary=1.00 cfs 2,091 cf Outflow=1.01 cfs 3,027 cf

Total Runoff Area = 15,112 sf Runoff Volume = 3,241 cf Average Runoff Depth = 2.57"
44.30% Pervious = 6,694 sf 55.70% Impervious = 8,418 sf

Summary for Subcatchment 4S: Post

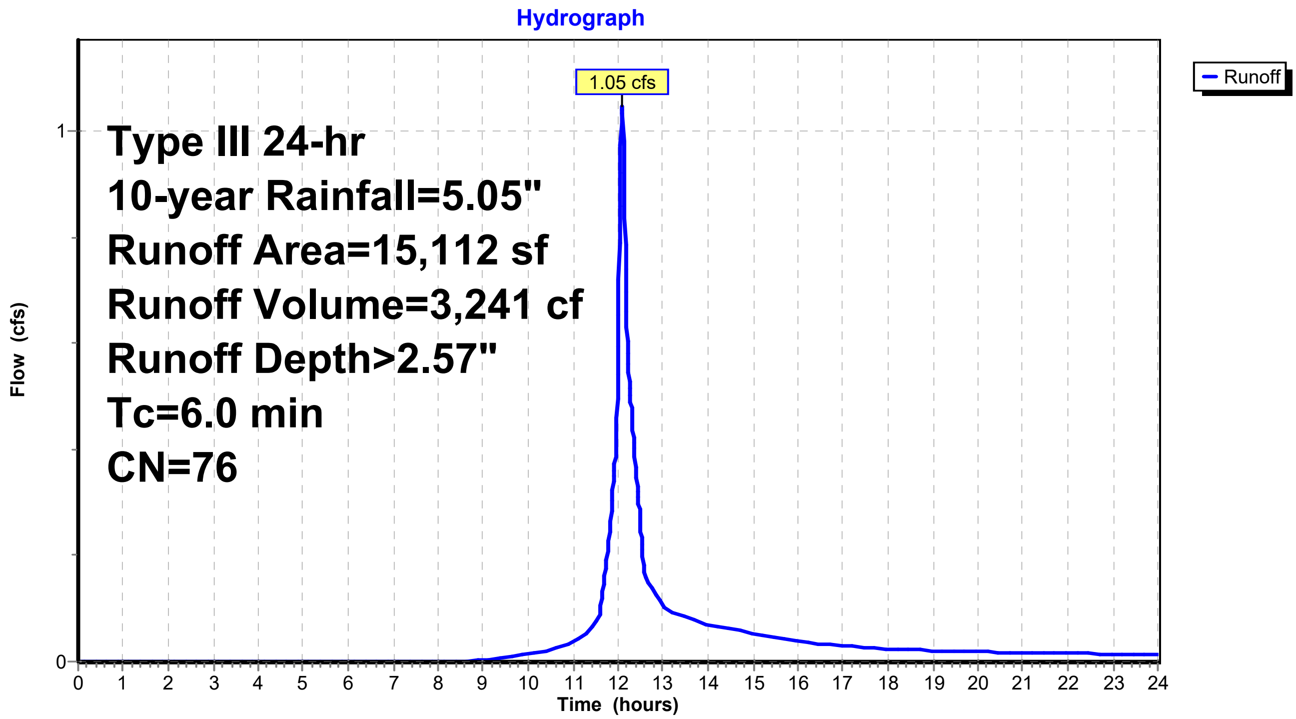
Runoff = 1.05 cfs @ 12.09 hrs, Volume= 3,241 cf, Depth> 2.57"
Routed to Pond 7P : 18" Pipe

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-year Rainfall=5.05"

Area (sf)	CN	Description
4,966	98	Roofs, HSG A
3,452	98	Paved parking, HSG A
6,694	49	50-75% Grass cover, Fair, HSG A
15,112	76	Weighted Average
6,694		44.30% Pervious Area
8,418		55.70% Impervious Area

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

Subcatchment 4S: Post

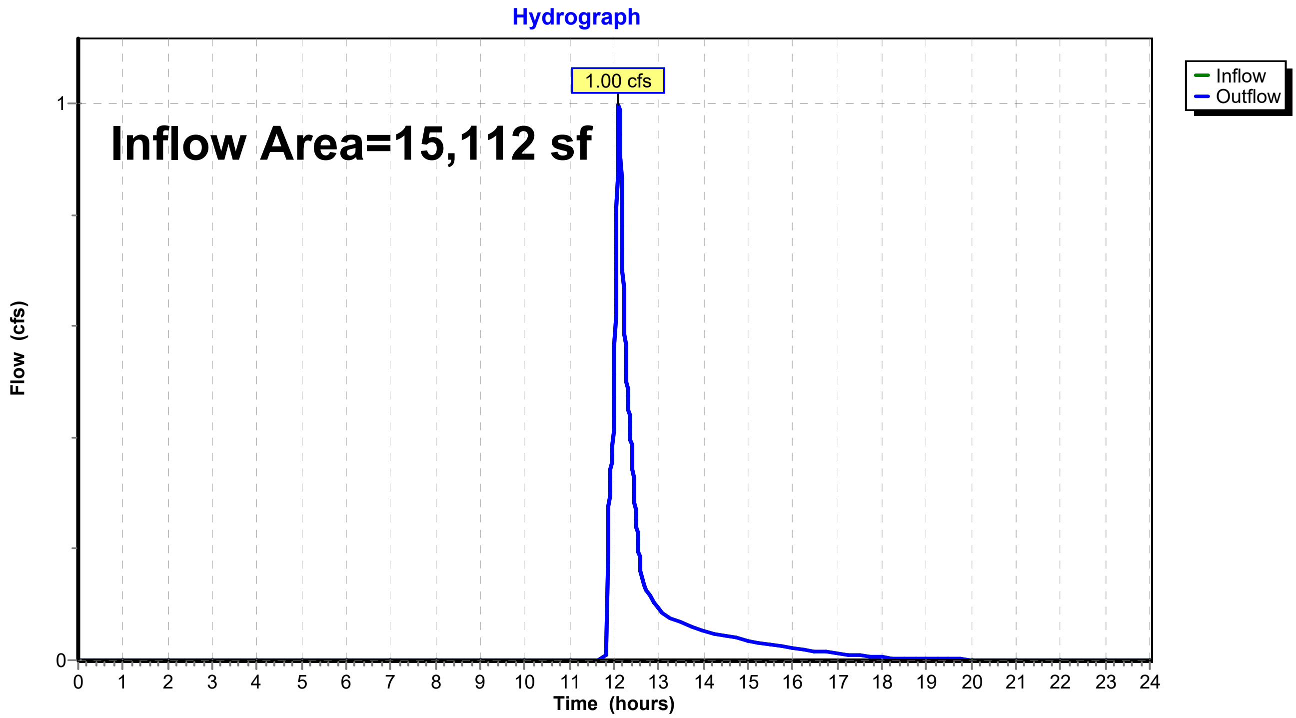


Summary for Reach 6R: Post

Inflow Area = 15,112 sf, 55.70% Impervious, Inflow Depth = 1.66" for 10-year event
Inflow = 1.00 cfs @ 12.11 hrs, Volume= 2,091 cf
Outflow = 1.00 cfs @ 12.11 hrs, Volume= 2,091 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Reach 6R: Post



Summary for Pond 7P: 18" Pipe

Inflow Area = 15,112 sf, 55.70% Impervious, Inflow Depth > 2.57" for 10-year event
Inflow = 1.05 cfs @ 12.09 hrs, Volume= 3,241 cf
Outflow = 1.01 cfs @ 12.11 hrs, Volume= 3,027 cf, Atten= 3%, Lag= 1.3 min
Discarded = 0.02 cfs @ 10.29 hrs, Volume= 936 cf
Primary = 1.00 cfs @ 12.11 hrs, Volume= 2,091 cf
Routed to Reach 6R : Post

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 18.17' @ 12.11 hrs Surf.Area= 323 sf Storage= 323 cf

Plug-Flow detention time= 52.9 min calculated for 3,027 cf (93% of inflow)
Center-of-Mass det. time= 18.5 min (849.6 - 831.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	16.00'	271 cf	**15.02'W x 21.50'L x 3.08'H Field A** 996 cf Overall - 223 cf Embedded = 773 cf x 35.0% Voids
#2A	17.00'	180 cf	**ADS N-12 18"** x 5 Inside #1 Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf 5 Chambers in 5 Rows
		451 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	16.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	17.55'	**12.0" Round Culvert** L= 7.5' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 17.55' / 17.45' S= 0.0133 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 0.79 sf
#3	Device 2	17.80'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 10.29 hrs HW=16.03' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.99 cfs @ 12.11 hrs HW=18.17' (Free Discharge)
└─**2=Culvert** (Barrel Controls 0.99 cfs @ 2.79 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Passes 0.99 cfs of 2.88 cfs potential flow)

Pond 7P: 18" Pipe - Chamber Wizard Field A

Chamber Model = ADS N-12 18" (ADS N-12® Pipe)
Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf
Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf

21.0" Wide + 14.3" Spacing = 35.3" C-C Row Spacing

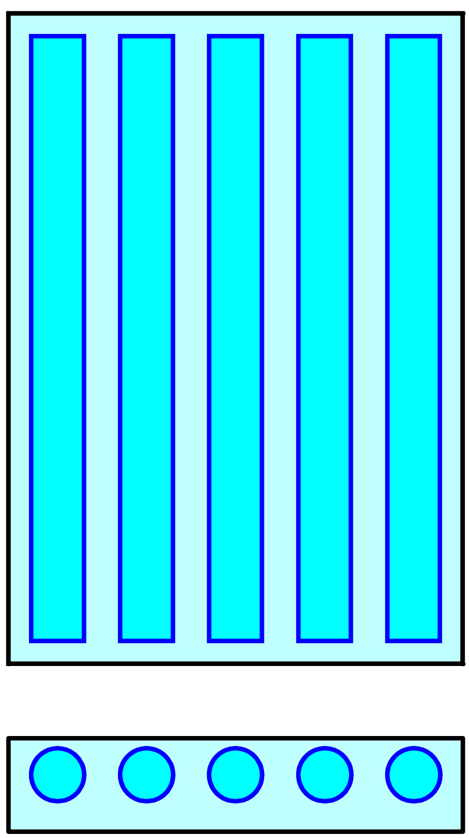
1 Chambers/Row x 20.00' Long = 20.00' Row Length +9.0" End Stone x 2 = 21.50' Base Length
5 Rows x 21.0" Wide + 14.3" Spacing x 4 + 9.0" Side Stone x 2 = 15.02' Base Width
12.0" Stone Base + 21.0" Chamber Height + 4.0" Stone Cover = 3.08' Field Height

5 Chambers x 36.0 cf = 180.0 cf Chamber Storage
5 Chambers x 44.5 cf = 222.6 cf Displacement

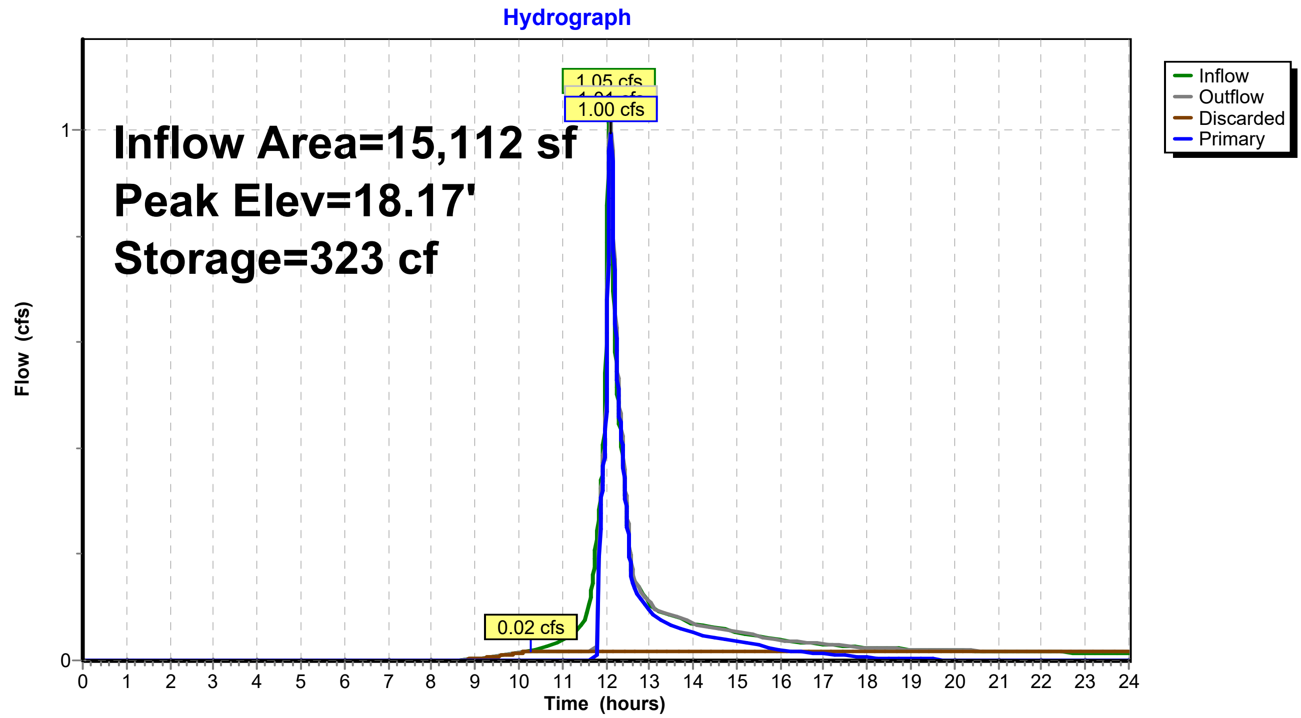
995.8 cf Field - 222.6 cf Chambers = 773.2 cf Stone x 35.0% Voids = 270.6 cf Stone Storage

Chamber Storage + Stone Storage = 450.6 cf = 0.010 af
Overall Storage Efficiency = 45.3%
Overall System Size = 21.50' x 15.02' x 3.08'

5 Chambers
36.9 cy Field
28.6 cy Stone



Pond 7P: 18" Pipe



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment4S: Post Runoff Area=15,112 sf 55.70% Impervious Runoff Depth>3.51"
Tc=6.0 min CN=76 Runoff=1.43 cfs 4,415 cf

Reach 6R: Post Inflow=1.37 cfs 3,186 cf
Outflow=1.37 cfs 3,186 cf

Pond 7P: 18" Pipe Peak Elev=18.31' Storage=350 cf Inflow=1.43 cfs 4,415 cf
Discarded=0.02 cfs 985 cf Primary=1.37 cfs 3,186 cf Outflow=1.39 cfs 4,171 cf

Total Runoff Area = 15,112 sf Runoff Volume = 4,415 cf Average Runoff Depth = 3.51"
44.30% Pervious = 6,694 sf 55.70% Impervious = 8,418 sf

Summary for Subcatchment 4S: Post

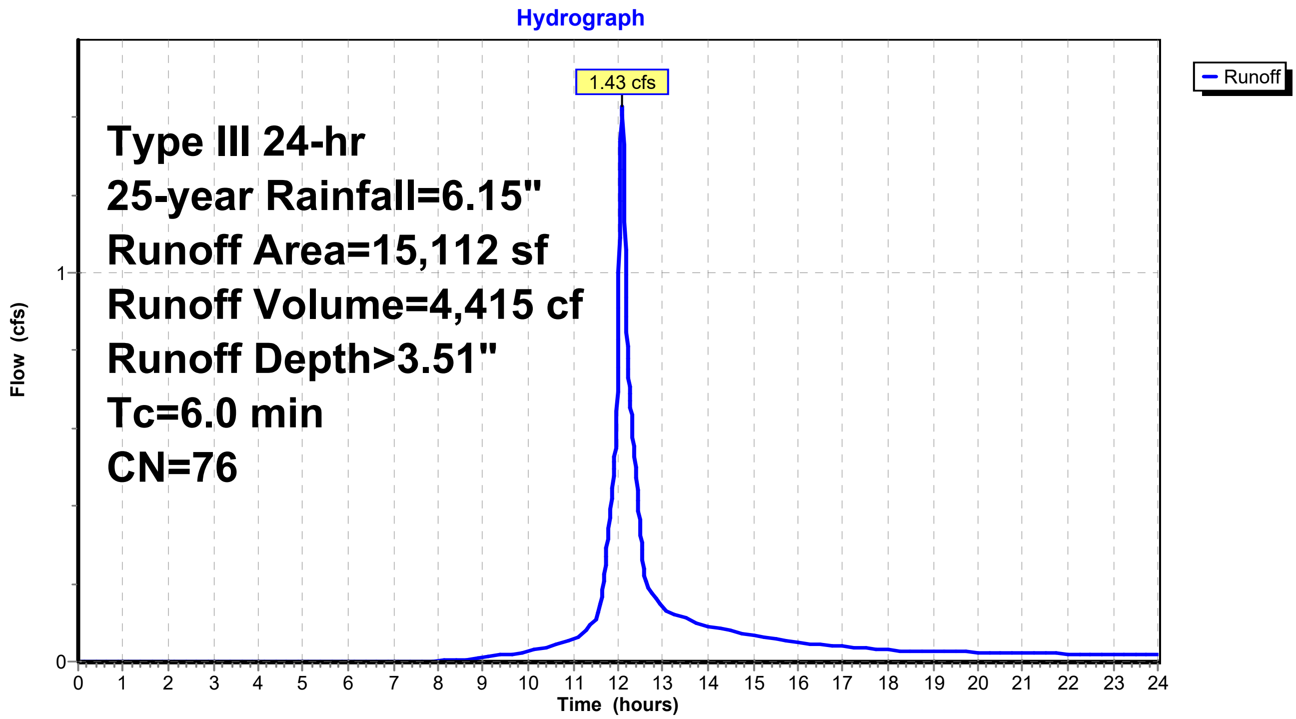
Runoff = 1.43 cfs @ 12.09 hrs, Volume= 4,415 cf, Depth> 3.51"
Routed to Pond 7P : 18" Pipe

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-year Rainfall=6.15"

Area (sf)	CN	Description
4,966	98	Roofs, HSG A
3,452	98	Paved parking, HSG A
6,694	49	50-75% Grass cover, Fair, HSG A
15,112	76	Weighted Average
6,694		44.30% Pervious Area
8,418		55.70% Impervious Area

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

Subcatchment 4S: Post

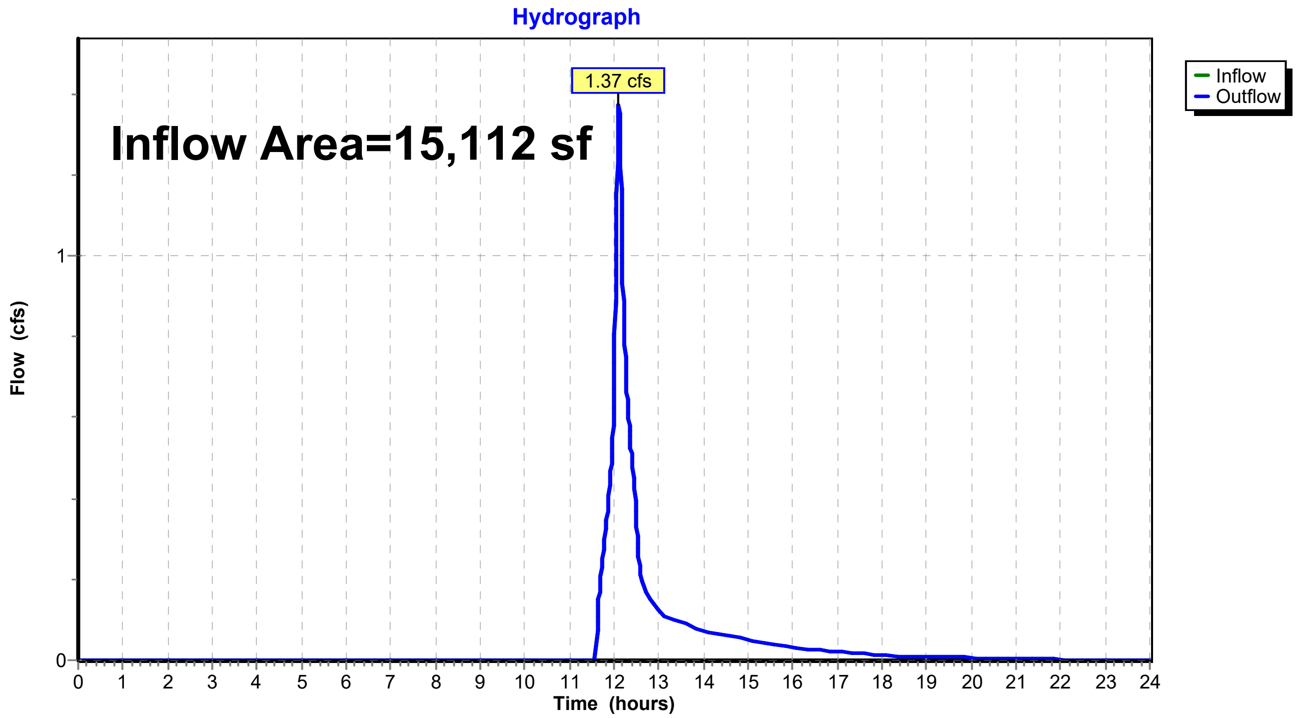


Summary for Reach 6R: Post

Inflow Area = 15,112 sf, 55.70% Impervious, Inflow Depth = 2.53" for 25-year event
Inflow = 1.37 cfs @ 12.11 hrs, Volume= 3,186 cf
Outflow = 1.37 cfs @ 12.11 hrs, Volume= 3,186 cf, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Reach 6R: Post



Summary for Pond 7P: 18" Pipe

Inflow Area =	15,112 sf, 55.70% Impervious,	Inflow Depth > 3.51" for 25-year event		
Inflow =	1.43 cfs @	12.09 hrs, Volume=	4,415 cf	
Outflow =	1.39 cfs @	12.11 hrs, Volume=	4,171 cf,	Atten= 3%, Lag= 1.1 min
Discarded =	0.02 cfs @	9.57 hrs, Volume=	985 cf	
Primary =	1.37 cfs @	12.11 hrs, Volume=	3,186 cf	

Routed to Reach 6R : Post

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 18.31' @ 12.11 hrs Surf.Area= 323 sf Storage= 350 cf

Plug-Flow detention time= 40.7 min calculated for 4,171 cf (94% of inflow)
Center-of-Mass det. time= 11.0 min (833.2 - 822.2)

Volume	Invert	Avail.Storage	Storage Description
#1A	16.00'	271 cf	**15.02'W x 21.50'L x 3.08'H Field A** 996 cf Overall - 223 cf Embedded = 773 cf x 35.0% Voids
#2A	17.00'	180 cf	**ADS N-12 18"** x 5 Inside #1 Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf 5 Chambers in 5 Rows
		451 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	16.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	17.55'	**12.0" Round Culvert** L= 7.5' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 17.55' / 17.45' S= 0.0133 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 0.79 sf
#3	Device 2	17.80'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 9.57 hrs HW=16.03' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=1.37 cfs @ 12.11 hrs HW=18.31' (Free Discharge)
└─**2=Culvert** (Barrel Controls 1.37 cfs @ 2.99 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Passes 1.37 cfs of 4.58 cfs potential flow)

Pond 7P: 18" Pipe - Chamber Wizard Field A

Chamber Model = ADS N-12 18" (ADS N-12® Pipe)
Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf
Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf

21.0" Wide + 14.3" Spacing = 35.3" C-C Row Spacing

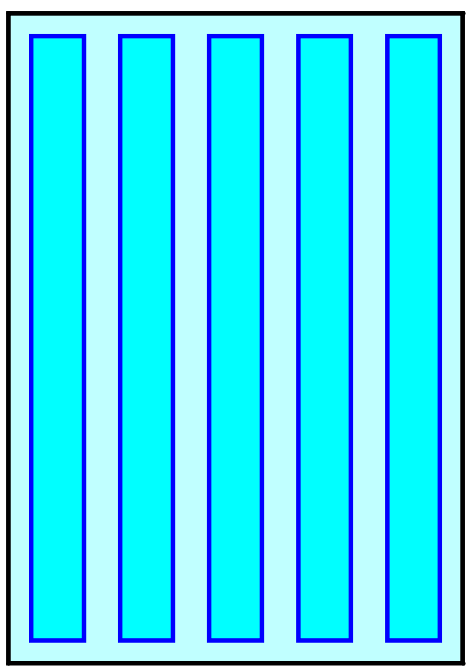
1 Chambers/Row x 20.00' Long = 20.00' Row Length +9.0" End Stone x 2 = 21.50' Base Length
5 Rows x 21.0" Wide + 14.3" Spacing x 4 + 9.0" Side Stone x 2 = 15.02' Base Width
12.0" Stone Base + 21.0" Chamber Height + 4.0" Stone Cover = 3.08' Field Height

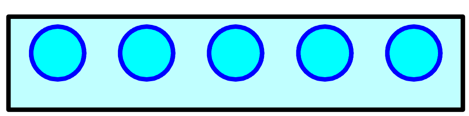
5 Chambers x 36.0 cf = 180.0 cf Chamber Storage
5 Chambers x 44.5 cf = 222.6 cf Displacement

995.8 cf Field - 222.6 cf Chambers = 773.2 cf Stone x 35.0% Voids = 270.6 cf Stone Storage

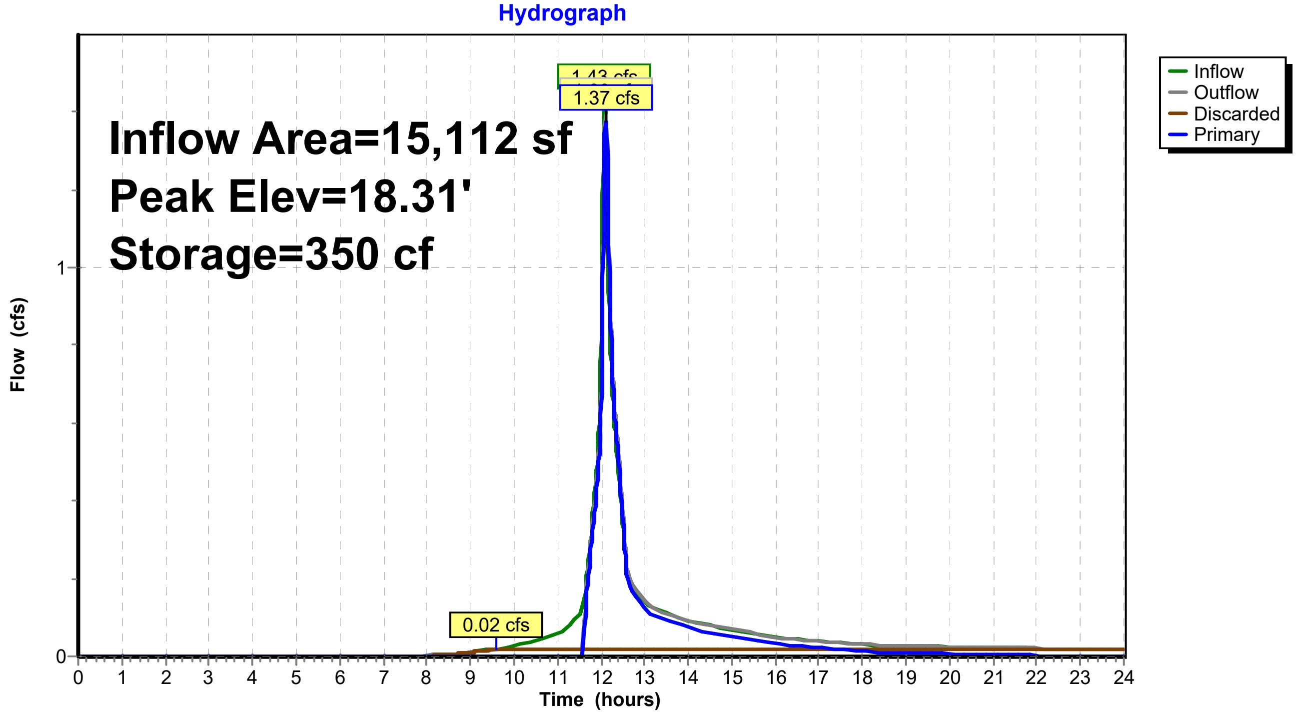
Chamber Storage + Stone Storage = 450.6 cf = 0.010 af
Overall Storage Efficiency = 45.3%
Overall System Size = 21.50' x 15.02' x 3.08'

5 Chambers
36.9 cy Field
28.6 cy Stone





Pond 7P: 18" Pipe



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment4S: Post Runoff Area=15,112 sf 55.70% Impervious Runoff Depth>5.03"
Tc=6.0 min CN=76 Runoff=2.04 cfs 6,329 cf

Reach 6R: Post Inflow=1.98 cfs 5,033 cf
Outflow=1.98 cfs 5,033 cf

Pond 7P: 18" Pipe Peak Elev=18.51' Storage=386 cf Inflow=2.04 cfs 6,329 cf
Discarded=0.02 cfs 1,047 cf Primary=1.98 cfs 5,033 cf Outflow=2.00 cfs 6,080 cf

Total Runoff Area = 15,112 sf Runoff Volume = 6,329 cf Average Runoff Depth = 5.03"
44.30% Pervious = 6,694 sf 55.70% Impervious = 8,418 sf

Summary for Subcatchment 4S: Post

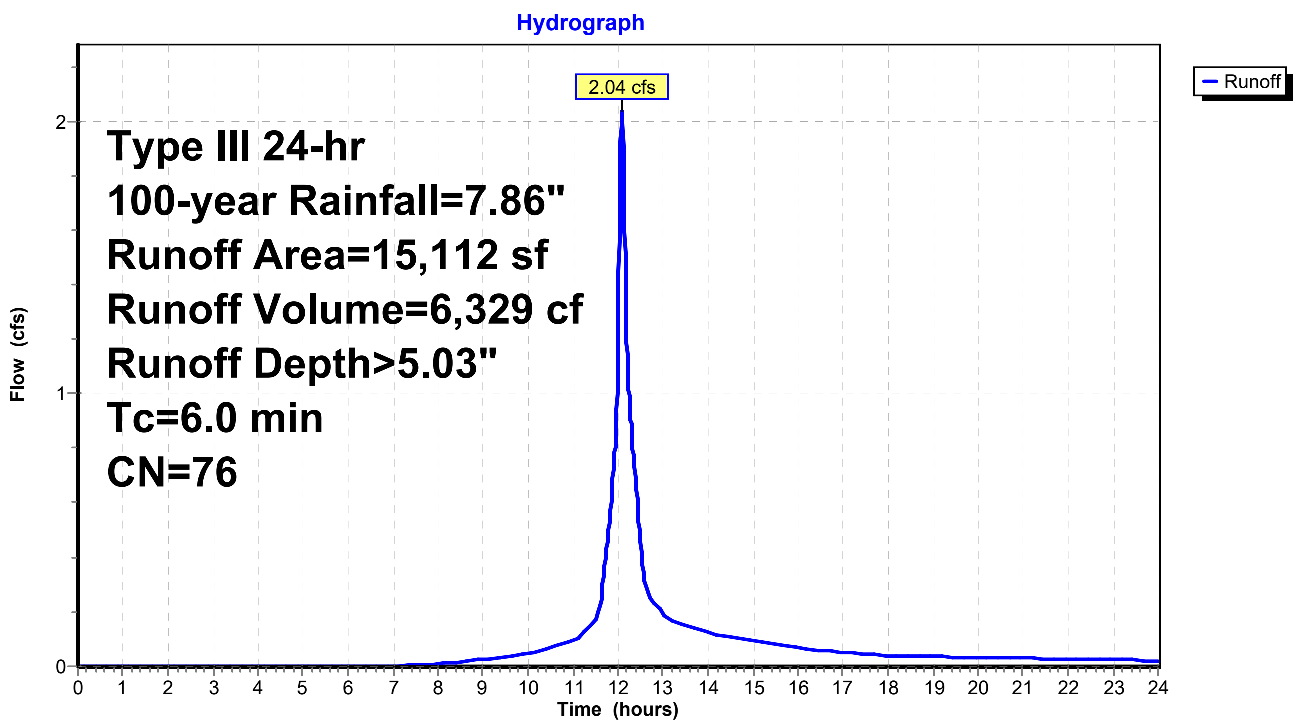
Runoff = 2.04 cfs @ 12.09 hrs, Volume= 6,329 cf, Depth> 5.03"
Routed to Pond 7P : 18" Pipe

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-year Rainfall=7.86"

Area (sf)	CN	Description
4,966	98	Roofs, HSG A
3,452	98	Paved parking, HSG A
6,694	49	50-75% Grass cover, Fair, HSG A
15,112	76	Weighted Average
6,694		44.30% Pervious Area
8,418		55.70% Impervious Area

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

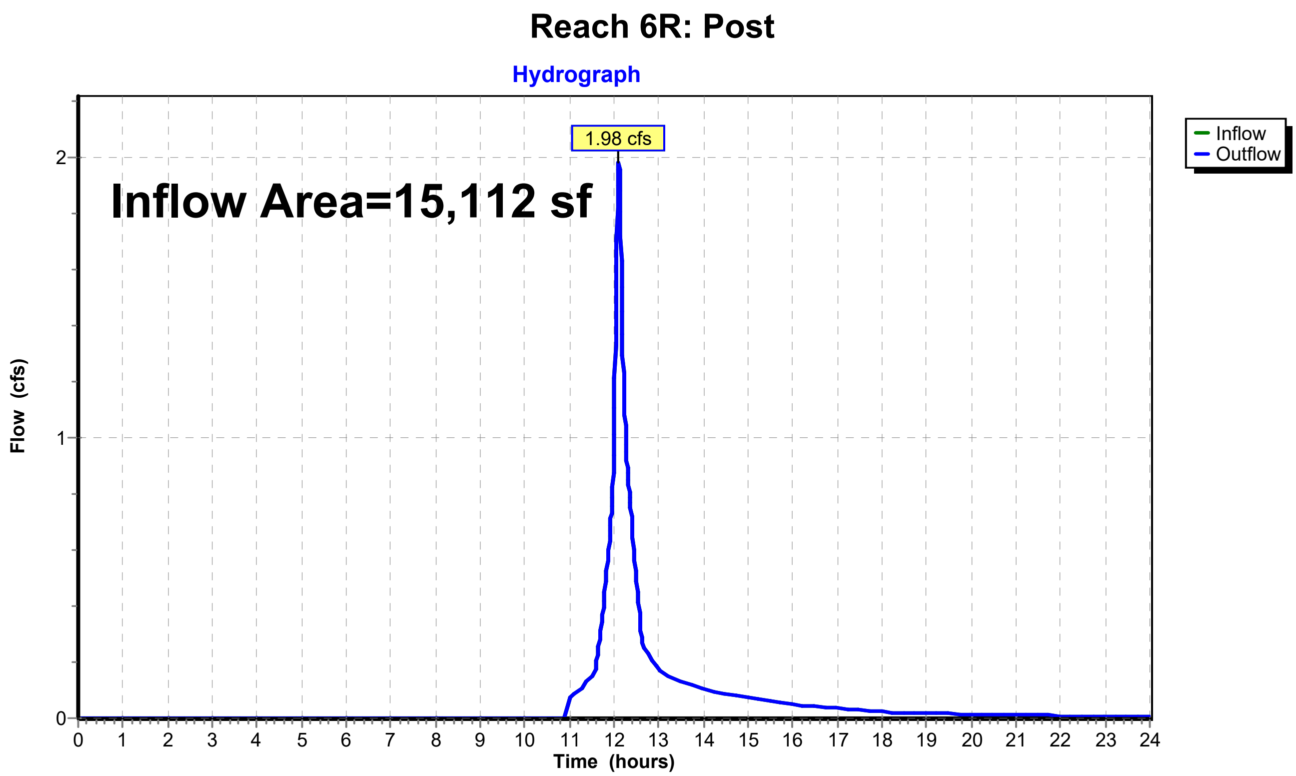
Subcatchment 4S: Post



Summary for Reach 6R: Post

Inflow Area =	15,112 sf, 55.70% Impervious,	Inflow Depth > 4.00"	for 100-year event
Inflow =	1.98 cfs @ 12.10 hrs, Volume=	5,033 cf	
Outflow =	1.98 cfs @ 12.10 hrs, Volume=	5,033 cf, Atten= 0%, Lag= 0.0 min	

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs



Summary for Pond 7P: 18" Pipe

Inflow Area = 15,112 sf, 55.70% Impervious, Inflow Depth > 5.03" for 100-year event
Inflow = 2.04 cfs @ 12.09 hrs, Volume= 6,329 cf
Outflow = 2.00 cfs @ 12.10 hrs, Volume= 6,080 cf, Atten= 2%, Lag= 0.9 min
Discarded = 0.02 cfs @ 8.67 hrs, Volume= 1,047 cf
Primary = 1.98 cfs @ 12.10 hrs, Volume= 5,033 cf
Routed to Reach 6R : Post

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 18.51' @ 12.10 hrs Surf.Area= 323 sf Storage= 386 cf

Plug-Flow detention time= 31.2 min calculated for 6,080 cf (96% of inflow)
Center-of-Mass det. time= 9.1 min (821.1 - 812.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	16.00'	271 cf	**15.02'W x 21.50'L x 3.08'H Field A** 996 cf Overall - 223 cf Embedded = 773 cf x 35.0% Voids
#2A	17.00'	180 cf	**ADS N-12 18"** x 5 Inside #1 Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf 5 Chambers in 5 Rows
		451 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	16.00'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	17.55'	**12.0" Round Culvert** L= 7.5' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 17.55' / 17.45' S= 0.0133 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 0.79 sf
#3	Device 2	17.80'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)

Discarded OutFlow Max=0.02 cfs @ 8.67 hrs HW=16.03' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=1.98 cfs @ 12.10 hrs HW=18.51' (Free Discharge)
└─**2=Culvert** (Barrel Controls 1.98 cfs @ 3.26 fps)
  └─**3=Sharp-Crested Rectangular Weir** (Passes 1.98 cfs of 7.58 cfs potential flow)

Pond 7P: 18" Pipe - Chamber Wizard Field A

Chamber Model = ADS N-12 18" (ADS N-12® Pipe)
Inside= 18.2"W x 18.2"H => 1.80 sf x 20.00'L = 36.0 cf
Outside= 21.0"W x 21.0"H => 2.23 sf x 20.00'L = 44.5 cf

21.0" Wide + 14.3" Spacing = 35.3" C-C Row Spacing

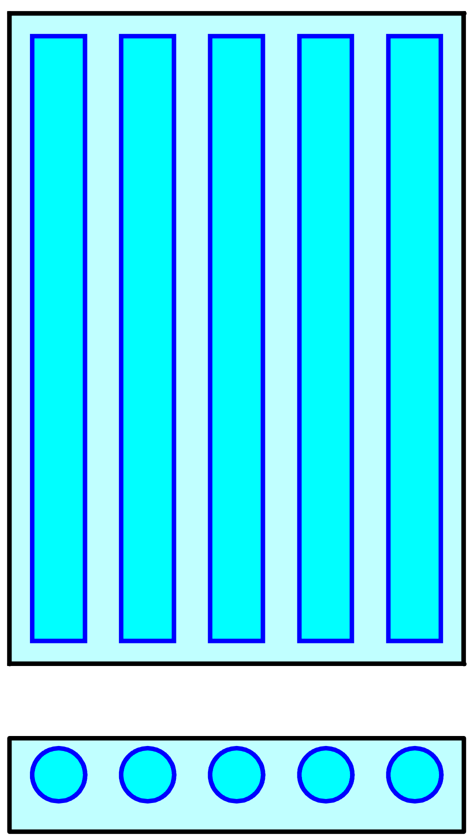
1 Chambers/Row x 20.00' Long = 20.00' Row Length +9.0" End Stone x 2 = 21.50' Base Length
5 Rows x 21.0" Wide + 14.3" Spacing x 4 + 9.0" Side Stone x 2 = 15.02' Base Width
12.0" Stone Base + 21.0" Chamber Height + 4.0" Stone Cover = 3.08' Field Height

5 Chambers x 36.0 cf = 180.0 cf Chamber Storage
5 Chambers x 44.5 cf = 222.6 cf Displacement

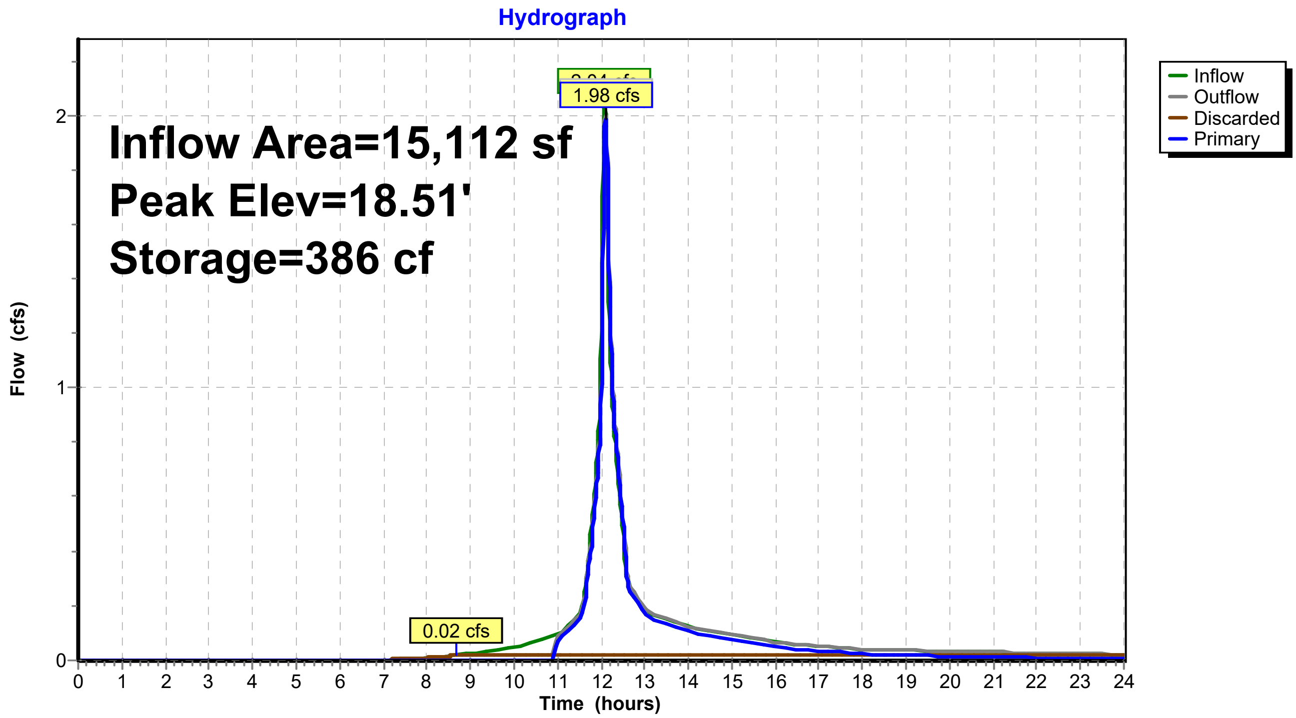
995.8 cf Field - 222.6 cf Chambers = 773.2 cf Stone x 35.0% Voids = 270.6 cf Stone Storage

Chamber Storage + Stone Storage = 450.6 cf = 0.010 af
Overall Storage Efficiency = 45.3%
Overall System Size = 21.50' x 15.02' x 3.08'

5 Chambers
36.9 cy Field
28.6 cy Stone



Pond 7P: 18" Pipe



APPENDIX C

Supplemental Information

NRCS Soil Maps and Descriptions

Geotechnical Report

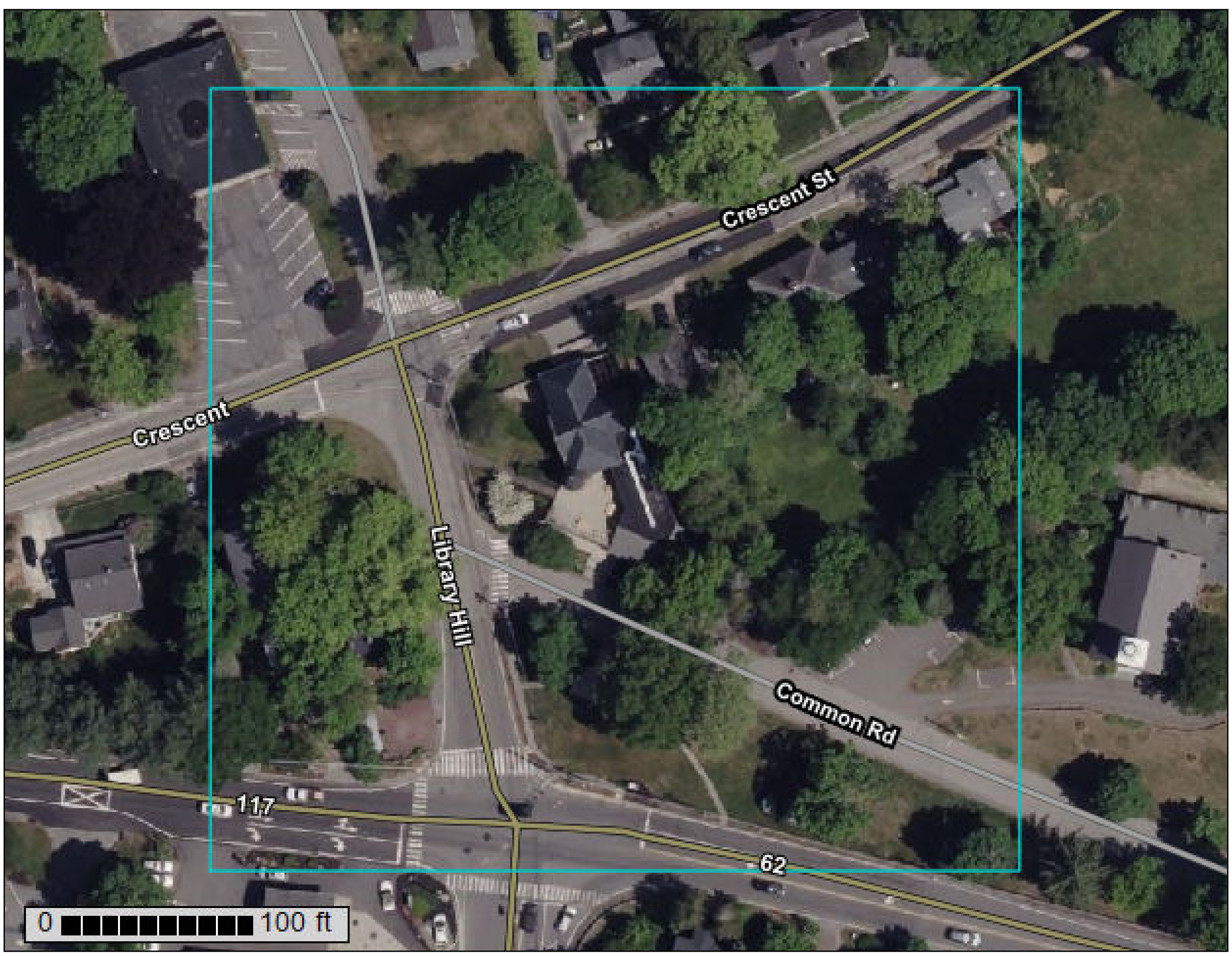
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

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

Custom Soil Resource Report for
Middlesex County, Massachusetts



June 22, 2023

Preface

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

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

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

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

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

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

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How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

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

Soil Map

Map Scale: 1:1,040 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 15, 30, 60, 90

Feet: 0, 50, 100, 200, 300

N

Map projection: Web Mercator   Corner coordinates: WGS84   Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Middlesex County, Massachusetts
Survey Area Data: Version 22, Sep 9, 2022

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

Date(s) aerial images were photographed: May 22, 2022—Jun 5, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
626B	Merrimac-Urban land complex, 0 to 8 percent slopes	3.9	100.0%
Totals for Area of Interest		**3.9**	**100.0%**

Map Unit Descriptions

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

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

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

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

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

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

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

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

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

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

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

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

Middlesex County, Massachusetts

626B—Merrimac-Urban land complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2tyr9
Elevation: 0 to 820 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 250 days
Farmland classification: Not prime farmland

Map Unit Composition

Merrimac and similar soils: 45 percent
Urban land: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Merrimac

Setting

Landform: Outwash plains, outwash terraces, moraines, eskers, kames
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Crest, side slope, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy glaciofluvial deposits derived from granite, schist, and gneiss over sandy and gravelly glaciofluvial deposits derived from granite, schist, and gneiss

Typical profile

Ap - 0 to 10 inches: fine sandy loam
Bw1 - 10 to 22 inches: fine sandy loam
Bw2 - 22 to 26 inches: stratified gravel to gravelly loamy sand
2C - 26 to 65 inches: stratified gravel to very gravelly sand

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline (0.0 to 1.4 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water supply, 0 to 60 inches: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: A

Ecological site: F144AY022MA - Dry Outwash
Hydric soil rating: No

Description of Urban Land

Typical profile

M - 0 to 10 inches: cemented material

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D
Hydric soil rating: Unranked

Minor Components

Windsor

Percent of map unit: 5 percent
Landform: Outwash terraces, dunes, outwash plains, deltas
Landform position (three-dimensional): Tread, riser
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Sudbury

Percent of map unit: 5 percent
Landform: Deltas, terraces, outwash plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Hinckley

Percent of map unit: 5 percent
Landform: Deltas, kames, eskers, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Head slope, nose slope, crest, side slope, rise
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

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Geotechnical Consultants, Inc.
(508)229-0900 FAX (508)229-2279

SUBSURFACE INVESTIGATION
AND
FOUNDATION RECOMMENDATIONS

Proposed Addition

Randall Library
19 Crescent Street
Stow, Massachusetts

prepared for

DesignLAB Architects
35 Channel Center Street, Suite 103
Boston, MA 02210

GEOTECHNICAL CONSULTANTS, INC.

Kayla Dooley

Daniel Kenneally, P.E.

GCI Project No. 2235310 **20 March 2023**

201 Boston Post Road West • Marlborough, Massachusetts 01752

Geotechnical Consultants, Inc.
(508)229-0900 FAX (508)229-2279

20 March 2023

DesignLAB Architects
35 Channel Center Street, Suite 103
Boston, MA 02210

Attention: Mr. Andrew Brookes

RE: Subsurface Investigation and Foundation Recommendations
Randall Library
19 Crescent Street- Stow, Massachusetts
GCI Project No. 2235310

Dear Mr. Brookes:

In accordance with our proposal dated 21 December 2022 and your authorization to proceed, we have completed a subsurface investigation and geotechnical evaluation for the proposed addition to the Randall Library in Stow, Massachusetts. This study has been conducted in general conformance with requirements of Section 780 CMR 1802.0 of the Massachusetts State Building Code for foundation investigations.

Presented herein and attached are the results of the investigation along with our recommendations concerning the design and construction of the proposed building addition foundation and other geotechnical related issues.

Information used to prepare this report, including existing site features, property boundaries and proposed building layout was obtained in part from the following sources:

- Electronic copy of the drawing set (28 sheets) titled “Randall Memorial Library Addition and Alterations” prepared by Finegold and Bullis Architects, dated 22 February 1974.
- The Bid Package titled “Request for Qualifications for Architect/Design Services” prepared by the Town of Stow, dated 26 October 2022.
- Discussions with the project team.

Elevations are referenced herein to the arbitrary datum on the Architectural drawings referenced above.

SITE DESCRIPTION AND PROPOSED DEVELOPMENT

The subject site is located at 19 Crescent Street on a 6,100± square foot parcel in Stow, Massachusetts. The site is located on the southeast corner of Crescent Street and West Acton Road in the town center of Stow and is known as the Randall Library. The general site vicinity is shown on the Locus Plan attached as Figure 1. and the present site building and nearby structures are shown on the Orthophoto Map attached as Figure 2.

Based on the Assessors Database for the Town of Stow, the original library building was constructed in 1894 and includes a 1½-story brick masonry structure with a finished raised basement, referred to as the first floor level. In 1920, an addition to the library's original building was constructed and is known as the Whitney Room. A larger addition was then constructed in 1975-1976. The first floor level has a slab on grade set at elevation 27.25± feet, according to the 1974 project plans and both additions have a first floor level slab on grade matching the original structure.

Surface grades throughout the site vary, sloping downward from the north to south, between elevations 22± and 36± feet.

Based on discussions with the project team, the proposed development was presented with three options and it has been decided to move forward with Option C to completely remove the existing library addition and construct a new building addition in its place. At the time of this report, the new addition is in the design/development stages and a finished floor elevation has not been provided. Based on the Option C schematics, the new addition will be at about street grade along Common Road, lower than the existing slab on grade. Underpinning of the existing structure foundations may need to be considered to ensure stability during construction.

SUBSURFACE INVESTIGATION & CONDITIONS

A subsurface investigation was conducted at the subject site on 27 February 2023 to determine the generalized subsurface conditions. The investigation consisted of three soil borings completed outside of the existing building addition and the approximate locations are shown on the Location Plan attached as Figure 3. The borings were completed by Carr Dee Corporation under the supervision and direction of Geotechnical Consultants, Inc. The boring locations were established in the field using tape surveying measurements from existing site features shown on the site plan provided. A copy of the boring logs are attached for reference.

Since the borings were completed outside the proposed addition, it is recommended that additional explorations are conducted within the building footprint area once the existing structure is demolished to confirm the soil profile encountered in this investigation.

The borings were advanced using a track drill rig using hollow stem augers. The borings extended to a depths ranging from approximately 11.5± to 20.75± feet below existing ground surface. In general, soil samples of the overburden were recovered at two to five foot intervals using a split spoon sampler driven in accordance with ASTM specification D1556. Soil samples recovered from the recently completed boring have been placed in storage in our laboratory and we will continue to store the samples for a period of not less than three months. Subsequently, the samples will be discarded unless otherwise directed.

Based on the results of the recently completed subsurface investigation, the general subsurface profile at the site includes:

- ***Fill:*** A layer consisting of medium to fine sand, little silt, little gravel with traces of loam and brick. The fill layer was approximately 3± to 6± feet thick; underlain by

- ***Sand & Gravel-*** A layer of medium dense to dense, medium to fine sand and gravel with varying proportions of silt. This layer was not penetrated as part of this investigation.

At borehole locations B-1 and B-2, "called refusal" was encountered at depths of 11.5± and 9.5± feet below the existing ground surface, respectively. Based on the surrounding site topography, it is possible that the depths to "called refusal" coincide with the top of bedrock.

During the time of our investigation, groundwater measurements were made upon completion of each borehole through the hollow stem augers. Using the short duration measurements, groundwater was encountered approximately 9± feet to 10.5± feet below the existing grade, corresponding to elevations from approximately 12± to 14± feet.

Fluctuations in groundwater levels should be expected and occur due to variations in season, precipitation, site features, and other environmental factors.

ANALYSIS AND RECOMMENDATIONS

The proposed building can be founded on conventional spread footings bearing on either the natural *Sand and Gravel* or structural backfill and the ground floor slab can be designed and constructed as a cast-in-place concrete slab-on-grade. Variations in the thickness of the fill should be anticipated and some over excavation may be required to ensure that all the fill is completely removed. Where over excavation is necessary, placement of structural backfill as described below is required.

Spread Footing Foundations

The new building foundations can be designed and constructed as typical spread footings. Given the expected slab elevations and site grading, it is anticipated the footings will bear on either the undisturbed *Sand and Gravel* stratum, or on compacted structural backfill. Footings can be sized for allowable contact pressure of up to 2 tons per square foot (4,000 psf) for subgrade consisting of either the undisturbed sand and gravel or structural backfill.

Given the anticipated foundation loads, minimum dimensions of two feet wide for strip footings and three feet square for individual column footings will likely govern regardless of the footing subgrade material.

Exterior footings must be placed at least to the minimum local frost depth. Although not explicitly stated in the current edition of the *Massachusetts State Building Code*, the local frost depth has historic ally been prescribed by code as four feet below finished exterior grade. In our opinion, the historic minimum frost depth should be maintained for this project.

Interior footings, both isolated column footings and strip footings, may bear at the highest elevation compatible with the lowest floor level. Lightly loaded interior partition walls, including non-load bearing masonry walls, can be supported on thickened portions of the floor slab.

Ground Floor Slab

The ground floor slab can be designed as a slab-on-grade supported directly on a granular subbase layer. The slab-on-grade should be supported on a layer of compacted structural backfill meeting the gradation limits for <u>imported</u> structural fill material provided below. Imported structural fill subbase should be at least 8-inches thick. The slab should be reinforced for crack control and the thickness can be determined using a modulus of subgrade reaction of 150 pci using either the PCA or WRI method.

Although vapor barriers may aggravate problems associated with plastic shrinkage and cracking, we recommend placing a vapor barrier directly below the slab in areas which will receive finishes such as coatings, tile or glued carpeting. The vapor barrier should consist of a Stego Wrap Vapor Barrier® by Stego Industries LLC, or equal, with a Water Vapor Transmission Rate of 0.3 perms or lower per ASTM E 96. Seams should be sealed in accordance with the manufacture's recommendation.

Where trenches are required for the placement of underslab utilities, backfill within the trenches must be adequately compacted to provide continuity of slab support. Trench backfill material should be consistent with the gradation of the slab subbase or as required for the specific utility application.

Waterproofing
The groundwater depths measured at the time of the borings indicate that groundwater is below the proposed addition slab level. Structures constructed below the slab level, such as the elevator pit, may be affected by the presence of groundwater.

We recommend below slab concrete structures be waterproofed using a chemical compound that crystallizes and chemically fuses to concrete and masonry to provide a watertight barrier. Products such as Xypex® or similar have proven to be effective and cost competitive. Xypex can be applied to the exposed concrete surface or mixed with the concrete at the time of placement. All concrete expansion joints and construction joints below grade should utilize adequate water stops.

Seismic Considerations
Earthquake loadings must be considered with respect to the requirements of Section 1613 of the *Massachusetts State Building Code*. In addition, the liquefaction potential of the underlying soils must be evaluated in accordance with Section 1806.4 of the *Massachusetts Code Amendments*.

Site classifications are based on the average density, and hence the ability of the soil to transmit shear waves during a seismic event. The average density is based on the material, both soil and rock, within 100 feet below the building. The site classification is then used to determine the site coefficient and mapped spectral response for a given structure.

The applicable seismic design criteria are as follows:

Site Class D: stiff soil profile

Spectral Response Acceleration at short period, S_s (Table 1604.11):	0.204g
Spectral Response Acceleration at 1 sec., S_1 (Table 1604.11):	0.069g
Site Coefficient, F_a (Table 1613.5.3(1)):	1.6
Site Coefficient, F_v (Table 1613.5.3(2)):	2.4
Adjusted spectral response, S_{Ms} (Equation 16-36):	0.326g
Adjusted spectral response, S_{M1} (Equation 16-37):	0.166g

Based on the result of the borings and in accordance with the provisions of the *Code*, the soils at the site are not considered susceptible to liquefaction.

CONSTRUCTION CONSIDERATIONS

The primary purpose of this section of the report is to comment on items related to excavation, foundation construction, earthwork and related geotechnical aspects of the proposed construction. It is written for the Architect and Engineer having responsibility for preparation of plans and specifications. Since it identifies potential construction problems related to foundations and earthwork, it will also aid personnel who monitor construction activities. Prospective contractors for this project must evaluate construction problems on the basis of their own knowledge and experience in the area, and on the basis of similar projects in other localities, taking into account their proposed construction procedures.

Excavation, Handling and Disposal of Fill Soils

Prior to construction, the fill and natural soils should be sampled and tested for the purpose of pre-classification for disposal, recycling, or reuse. The construction documents should include provisions for soil management and require the Contractor to develop, implement, and supervise a Worker Health and Safety Program. The construction phase-specific plan, should incorporate, at a minimum, a general Health and Safety Program to limit safety-related accidents and to promote health in the construction workplace. The Program should include provisions which will limit exposures of workers to contaminants through ingestion, dermal contact and inhalation.

The soil management plan must be developed in cooperation with the project environmental consultant. The contents of the soil management plan will depend upon the nature and character of the fill soils. Disposal and recycling of all classified soils from excavation activities must be performed in general conformance with applicable Federal, State and Local regulations governing Oils and Hazardous Materials (OHMs).

Cuts and Excavations

All excavations must comply with the Occupational Safety and Health Administration (OSHA) Regulations concerning sloped cuts. The strata encountered at the test pits can be classified as follows:

Fill layer:	Type “C” - maximum allowable slope of 1.5H:1V
Sand & Gravel:	Type “C” - maximum allowable slope of 1.5H:1V

These classifications are provided only as a preliminary construction guide and may not reflect the actual soil conditions encountered during excavation. Soil conditions of sloped or benched cuts should be inspected by a qualified engineer to determine actual soil conditions and allowable slope.

Underpinning

Based on the information provided at the time of this report, the new addition will likely be set at a finished floor elevation lower than the existing structure. The existing structure is founded on rubble foundations and, prior to construction, test pits should be performed to expose a portion of the existing foundation and determine the bearing depth. Depending on the existing conditions underpinning may be required to ensure stability of the foundations during construction of the new spread footing foundations.

Subgrade Preparation and Maintenance

Recommendations regarding the design of the spread footings and slab-on-grade at the ground floor level are only valid if the site is prepared as described below. It is presumed the existing addition will be completely demolished and removed from the site within the proposed footprint of the new addition.

Beneath all building footings and the slab-on-grade area, all fill must be completely removed. Based on the recent boring information, the fill soils outside of the addition footprint extend approximately 3± to 6± feet below the existing ground surface, corresponding to elevations between 16.5± and 21± feet.

After excavation to the required depths it is recommended the exposed subgrade be heavily proof compacted using a vibratory drum roller having a minimum drum width of at least eight feet and a rated dynamic weight of at least 20 tons. In order to maximize the vibratory densification process, proof-rolling should be performed with the roller operating at maximum amplitude. Each roller pass should be made in perpendicular directions to one another to ensure full coverage.

Should "weak" spots be encountered during the proof-rolling operation, they should be investigated by excavating test pits to identify the specific, localized conditions. Unsuitable soils, including highly organic, deleterious, or decayable materials, must be removed. Where over excavation is required to remove the fill or other materials unsuitable for load support, the subgrade should be proof compacted in preparation for the placement of compacted structural backfill.

All backfill placed within the building area, whether consisting of previously excavated granular soil or imported material must be placed in 12-inch loose lifts and compacted to a modified Proctor density of 95 per cent (ASTM D1557). Imported material used for structural backfill and the subbase below the slab, must consist of clean, well-graded granular soil or other dense processed aggregate free of organic material, loam, asphalt, snow, ice, frozen soil and other objectionable materials. Gradation limits for <u>imported</u> material used for structural backfill should be as follows and have no stones larger than 3" (three inches):

Sieve Size	Percent Passing
3"	100
½"	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-8

Based on the groundwater measurements made at the time of our investigation, we do not anticipate general site dewatering will be needed during site preparation or foundation construction. However, adequate site drainage must be provided to preclude the accumulation of surface water within the building footprint area. Drainage or dewatering, where needed, must be done so that all work can proceed in-the-dry. It is imperative that all exposed subgrade soils be protected from water and prolonged exposure to freezing temperatures.

Excavation for footings and exposed subgrade should be inspected by a qualified geotechnical engineer to ensure adequacy of the subgrade soils. The placement of all structural backfill must be inspected and certified as to its adequacy and conformity to the requirements of the *Massachusetts State Building Code*.

Backfill soil placed outside the building footprint in areas of non-load support may be “ordinary fill”. Ordinary fill should consist of granular soil containing no decayable matter such as roots, wood, organic soil, etc. Ordinary fill should be placed in layers and compacted with available construction equipment to reduce future settlement.

Construction Monitoring

We recommend that you retain Geotechnical Consultants, Inc. to review your foundation and construction plans for compliance with our geotechnical recommendations. We recommend that Geotechnical Consultants, Inc. also be retained to provide construction observation services during construction to prepare reports in order to satisfy the Massachusetts State Building Code's Special Inspections Reporting requirements (refer to Chapter 17). We strongly recommend that Geotechnical Consultants, Inc. be retained to observe and document the following key geotechnical components of construction:

- Site preparation;
- Placement and compaction of fill materials;
- Final preparation of foundation and slab subgrades;
- Placement of all concrete; and
- Erection of structural steel and/or timber.

Our involvement during construction will allow evaluation of actual conditions exposed during excavation, and to allow a prompt response should unanticipated conditions be encountered. Our involvement will also efficiently facilitate the field-assessment of areas where partial over excavation of existing soils may be warranted, thereby saving the Owner time and money.

LIMITATIONS

This report has been prepared for specific application to the proposed addition located at 19 Crescent Street in Stow, Massachusetts in accordance with generally accepted geotechnical engineering practices. The recommendations provided herein are based on information of subsurface conditions and proposed construction that is available to us at this time. As the design development progresses, implementation of these recommendations must consider any variations from the currently anticipated construction. The nature and extent of variations in the subsurface conditions between explorations may not be evident until construction. If significant variations appear, it will be necessary to re-evaluate the recommendations presented in this report.

We request that we be provided the opportunity for a general review of the applicable contract drawings and specifications, to determine that our recommendations have been interpreted and implemented as they were intended. If any changes in the nature, design or location of the proposed building is made, we should review the applicability of our recommendations.

It has been our pleasure serving you and we trust that the foregoing and attached are sufficient for your immediate needs. Should you have any questions, or need further assistance, please do not hesitate to contact this office.

Sincerely,
GEOTECHNICAL CONSULTANTS, INC.

Kayla J. Dooley
Kayla Dooley

Daniel Kenneally, P.E.

DK/kd
Attachments

Randall Library
19 Crescent Street
Stow, Massachusetts

N

LOCUS PLAN
U.S.G.S. HUDSON QUADRANGLE
APPROX. SCALE 1:24 000

Geotechnical Consultants, Inc.
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Marlborough, MA 01752
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GCI Project # 2235310

Figure 1.

Randall Library
19 Crescent Street
Stow, Massachusetts
GCI Project No. 2235310

Figure 2.
Color Orthophoto Map

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201 Boston Post Road West
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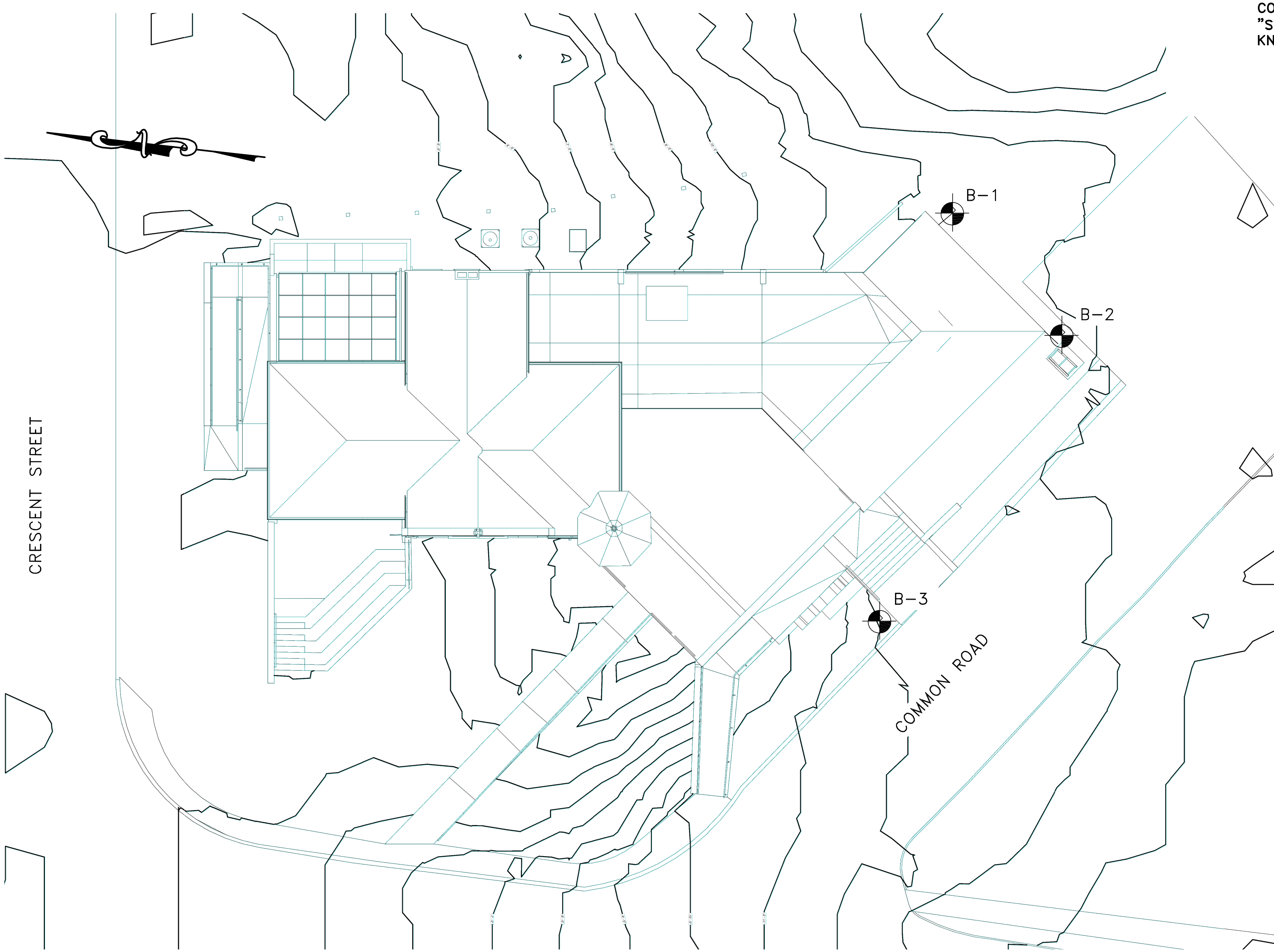
LEGEND

APPROXIMATE LOCATION OF BORINGS PERFORMED BY CARR–DEE CORP., UNDER THE DIRECTION OF GEOTECHNICAL CONSULTANTS, INC. ON 27 FEBRUARY 2023.

BASE PLAN TAKEN FROM AN ELECTRONIC COPY OF A DRAWING XC1.3 ENTITLED "SITE PLAN" PREPARED BY POINT KNOWN, DATED 3 FEBRUARY 2023.



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LOCATION PLAN

(feet) 0 10 20

MARCH 2023

Randall Library
19 Crescent Street
Stow, Massachusetts

FIGURE 3.

APPENDIX A
Boring Logs

CARR-DEE CORP.

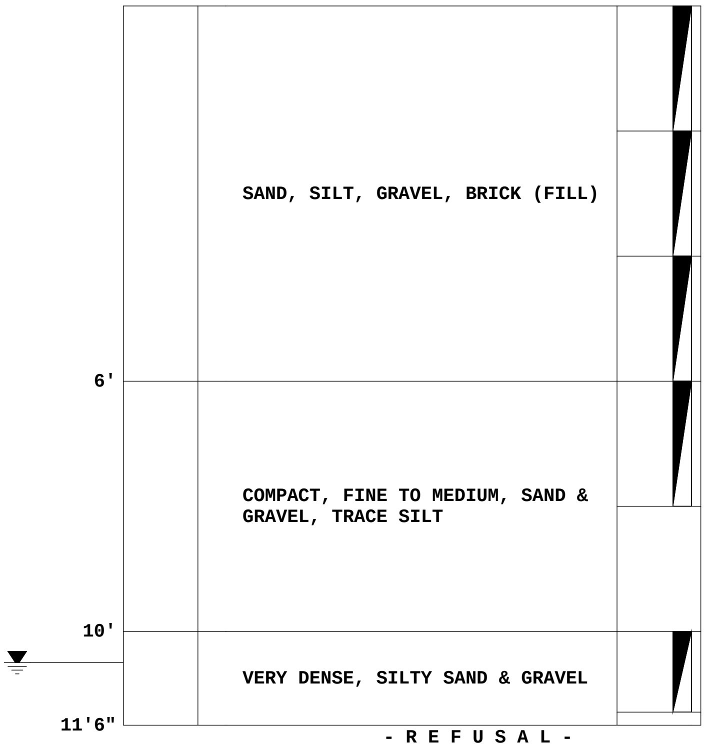
37 LINDEN STREET MEDFORD, MA 02155-0001 Telephone (781) 391-4500

To: GEOTECHNICAL CONSULTANTS INC., MARLBOROUGH, MA Date: 2-28-2023 Job No.: 2023-13

Location: PUBLIC LIBRARY, 19 CRESCENT ST., STOW, MA Scale: 1 in.= 3 ft.

BORING 1

GROUND SURFACE



S#1, 0' to 2'
(3-3-6-6)
RECOVERED 12 in.

S#2, 2' to 4'
(7-3-3-7)
RECOVERED 12 in.

S#3, 4' to 6'
(3-3-4-5)
RECOVERED 4 in.

S#4, 6' to 8'
(8-11-10-10)
RECOVERED 14 in.

S#5, 10' to 11'3"
(24-60-100/3)
RECOVERED 10 in.

- R E F U S A L -
(NO PENETRATION WITH AUGERS)

WATER LEVEL 10'6"
SIZE OF AUGERS: 2 1/4"I.D., LENGTH: 11'6"
DRILLER: S. DESIMONE JR., INSPECTOR: V. HULTGREN
DATE STARTED & COMPLETED: 2-27-2023

All samples have been visually classified by . Unless otherwise specified, water levels noted were observed at completion of borings, and do not necessarily represent permanent ground water levels. Figures in parenthesis indicate the number of blows required to drive Two-inch Split Sampler 6 inches using 140 lb. weight falling 30 inches(±). Figures in column to left (if noted) indicate number of blows to drive casing one foot, using 300 lb. weight falling 24 inches (±).

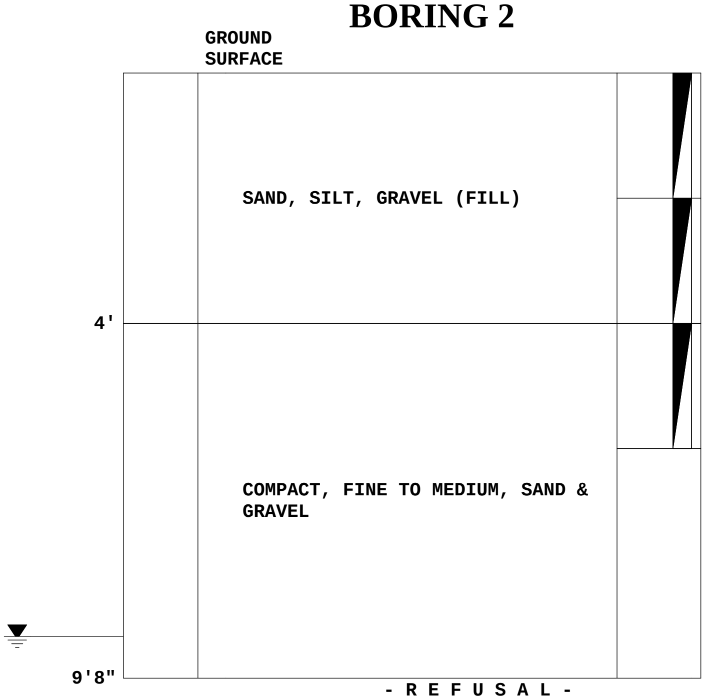
CARR-DEE CORP.

37 LINDEN STREET MEDFORD, MA 02155-0001 Telephone (781) 391-4500

To: GEOTECHNICAL CONSULTANTS INC., MARLBOROUGH, MA Date: 2-28-2023 Job No.: 2023-13

Location: PUBLIC LIBRARY, 19 CRESCENT ST., STOW, MA Scale: 1 in.= 3 ft.

BORING 2



S#1, 0' to 2'
(6-6-13-15)
RECOVERED 12 in.

S#2, 2' to 4'
(2-2-12-11)
RECOVERED 4 in.

S#3, 4' to 6'
(21-14-12-12)
RECOVERED 12 in.

- R E F U S A L -
(NO PENETRATION WITH AUGERS)

WATER LEVEL 9'
SIZE OF AUGERS: 2 1/4"I.D., LENGTH: 9'8"
DRILLER: S. DESIMONE JR., INSPECTOR: V. HULTGREN
DATE STARTED & COMPLETED: 2-27-2023

All samples have been visually classified by . Unless otherwise specified, water levels noted were observed at completion of borings, and do not necessarily represent permanent ground water levels. Figures in parenthesis indicate the number of blows required to drive Two-inch Split Sampler 6 inches using 140 lb. weight falling 30 inches(±). Figures in column to left (if noted) indicate number of blows to drive casing one foot, using 300 lb. weight falling 24 inches (±).

CARR-DEE CORP.

37 LINDEN STREET MEDFORD, MA 02155-0001 Telephone (781) 391-4500

To: GEOTECHNICAL CONSULTANTS INC., MARLBOROUGH, MA Date: 2-28-2023 Job No.: 2023-13

Location: PUBLIC LIBRARY, 19 CRESCENT ST., STOW, MA Scale: 1 in.= 3 ft.

BORING 3

GROUND SURFACE

0' to 3'	SAND, SILT, GRAVEL, LOAM (FILL)
3' to 5'	COMPACT, FINE TO MEDIUM, SAND & GRAVEL, SOME SILT
5' to 10'	LOOSE, FINE TO MEDIUM, SAND & GRAVEL, SOME SILT
10' to 14'	COMPACT TO DENSE, FINE TO MEDIUM, SAND & GRAVEL, SOME SILT
14' to 20'9"	VERY DENSE, FINE TO MEDIUM, SAND & GRAVEL, SOME SILT

S#1,	0' to 2'	(1-1-6-3)	RECOVERED 6 in.
S#2,	2' to 3'	(6-17)	RECOVERED 6 in.
S#2A,	3' to 4'	(16-14)	RECOVERED 6 in.
S#3,	5' to 7'	(2-4-6-12)	RECOVERED 14 in.
S#4,	10' to 12'	(6-6-7-13)	RECOVERED 12 in.
S#5,	12' to 14'	(12-15-30-24)	RECOVERED 14 in.
S#6,	15' to 17'	(18-50-42-35)	RECOVERED 15 in.
S#7,	20' to 20'9"	(44-100/3)	RECOVERED 3 in.

WATER LEVEL 10'
SIZE OF AUGERS: 2 1/4"I.D., LENGTH: 20'0"
DRILLER: S. DESIMONE JR., INSPECTOR: V. HULTGREN
DATE STARTED & COMPLETED: 2-27-2023

All samples have been visually classified by . Unless otherwise specified, water levels noted were observed at completion of borings, and do not necessarily represent permanent ground water levels. Figures in parenthesis indicate the number of blows required to drive Two-inch Split Sampler 6 inches using 140 lb. weight falling 30 inches(±). Figures in column to left (if noted) indicate number of blows to drive casing one foot, using 300 lb. weight falling 24 inches (±).