ACORN ENGINEERING, INC.

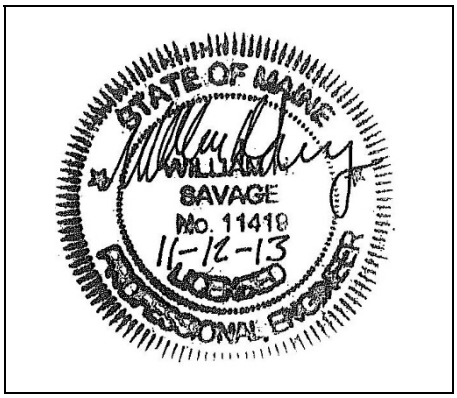
STORMWATER MANAGEMENT REPORT

Prepared For:

Redfern Properties, LLC
Munjoy Heights
79 Walnut Street
Portland, Maine 04101

Prepared By:

Acorn Engineering, Inc.
P.O. Box 3372
Portland, Maine 04104



November 2013

INTRODUCTION

Acorn Engineering, Inc. has been retained by Redfern Properties, LLC to provide civil engineering services for the proposed development of Munjoy Heights located at 79 Walnut Street in Portland, Maine. Munjoy Heights is a 29-unit vertical urban infill development set on the western slopes of Munjoy Hill. At the private driveway elevation each two to four story unit will have a dedicated garage with approximately 1,900 to 2,400 square feet (sf) of livable space comprised of units with 3 bedrooms.

A stormwater analysis will be prepared to demonstrate that the project will meet the following requirements of the City of Portland (the City):

- City of Portland Land Use Ordinance Chapter 14, Article V. Site Plan Section 14-523. Required Approvals and Applicability (F) Level III Site Plan Review.
- City of Portland Technical Manual – Section 5 – Portland Stormwater Management Standards and Maine DEP Chapter 500 Stormwater Management.

On July 19th, 2013 representatives of Acorn Engineering met with David Margolis-Pineo and Doug Roncarati to discuss the proposed stormwater connection to the municipal sewer system. Potential locations include the intersection of Eastern Promenade and Washington Avenue, East Cove Street, the intersection of Washington Avenue and Fox Street as well as the intersection of Sheridan Street and Walnut Street.

At the meeting Acorn Engineering was informed that the storm sewer located at the Walnut Street and Sheridan Street intersection towards Washington Avenue has been identified by the City as a proposed green infrastructure storm sewer separation project. The green infrastructure storm sewer separation project is part of the City of Portland's Combined Sewer Overflow Tier III Improvement Plan and that the cost of such improvements would be paid for and implemented by the City.

Based upon our discussion, both parties agreed that connecting the proposed Munjoy Heights storm drainage to the existing Walnut Street combined sewer would be the best course of action and would facilitate the future connection to the separated municipal storm drainage network.

The proposed project will include the redevelopment of existing impervious area including rooftops, asphalt and gravel driveways and parking. The current course of action is to provide water quality treatment to the stormwater through filtration and infiltration utilizing a Maine Department of Environmental Protection - Underdrained Subsurface Sand Filter approved stormwater Best Management Practice (BMP). This development shall incorporate green infrastructure to provide water quality treatment for no less than 95% of the new impervious area and 80% of the developed area.

The stormwater analysis is documented with supporting calculations and reports attached to this narrative.

EXISTING CONDITIONS

The proposed project is located to the west of 79 Walnut Street in Portland. The proposed lot is a combination of multiple properties which presently include Portland Tax Map 012, Block H, Lots 1, 3, 5, 7, 9 (portion), 13, 17 and 22, Block G, Lot 6, and Block F, Lots 2 (portion), 4, 7, 18, 19 and 20 that consists of 66,624 square feet (1.53 acres) of land area. Portland has zoned this area as an R-6 Residential Zone. An existing conditions plan has been prepared by Nadeau Land Surveys of Portland, Maine.

Abutting Uses:

- North R-6 Zone - Volunteers of America and Residences
- West R-6 Zone - Northern Burner Supply
- South R-6 and B2B Zone - Single and Multi-Family Residential
- East R-6 Zone - Single and Multi-Family Residential

The existing vacated paper street will also be claimed and is 20,684 square feet (0.47 acres) of land area. There is an existing two story building residing on Block H, Lot 9 which shall remain with a reconfigured lot line. The single family on Block F, Lot 19 and 20 and multi-family on Block H, Lot 17 shall be removed.

The majority of the project area is comprised of tree cover with grassed areas adjacent to the single and multi-family properties. Impervious areas include the existing buildings as well as paved and gravel driveways. From southeast to northwest the existing grades go from gradual to relatively steep with much of the slope at approximately 25%.

The project area presently drains towards Washington Ave before entering the municipal combined sewer system. The Washington Ave combined sewer conveys flow towards Anderson St and ultimately on to the Portland Water District - East End Wastewater Treatment Facility. At this location inflow enters the system through existing separated drainage from Sheridan Street and then recombines into the combined sewer that recombines within Walnut Street. The Walnut Street CSO crosses Washington Ave at which time it runs parallel to a separate drainage system. The distance between the separated drainage is approximately 382 ft. Separating the 382 ft. of CSO is part of the green infrastructure storm sewer separation project described within the City of Portland's Combined Sewer Overflow Tier III Improvement Plan.

The project team is not aware of the presence of any existing significant natural features located on the site. Given the urban setting, existing free-draining soils and steep slopes a field inventory of significant natural feature was not undertaken. The project is not located within a watershed classified as an Urban Impaired Stream.

PROPOSED DEVELOPMENT

Munjoy Heights is a twenty nine unit vertical urban infill development set on the western slopes of Munjoy Hill. At the private driveway elevation each two to four story unit will have a dedicated garage with a minimum of one parking space with additional room for solid waste/recycling. Parking will be supplemented with five surface parking spaces to be used by residents and their guests. To minimize the developments footprint and amount of

impervious area, the driveway is reduced to a minimum width of twenty feet and the units have been clustered together.

The driveway grading profile will follow the natural topography with proposed 1% slopes. As described in the existing conditions, the significant topographic relief will occur from East to West. The goal of the project is to work with the existing conditions, specifically topography. To the greatest extent practical this is achieved through the reduction of surface parking through the use of garage parking spaces, a reduction in the overall private driveway width and terracing the townhomes into the slope. Terracing will be completed through stepped foundations and retaining walls. The retaining walls are setback a minimum distance of 8-10 ft to from the building to reduce the size of the developments footprint while providing access to the exterior of the buildings. Summit Geoengineering Services in coordination with Structural Integrity Consulting Engineering will provide the retaining wall design. The retaining walls shall be of made of durable and attractive materials with a high architectural quality.

Landscaping shall be incorporated into the development to compliment the contemporary townhomes while offering environmental benefits such as reducing the heat island effect, stormwater quality treatment and screening the proposed retaining walls from abutting residences. Landscaping design shall be provided by Soren Deniord Design Studio.

The development team continues to collaborate with Portland Trails to provide a inviting route through the development from Walnut Street to the existing Portland Trails "Jack Path" at the northwest property line. Although a permanent access easement does not presently existing the client has proposed granting one to Portland Trails.

The development will be served by the Portland Water District, underground power/cable/communications, natural gas and the municipal sewer system. Solid waste and recycling will be contracted through a private waste disposal and recycling provider.

The project anticipates incorporating Maine DEP approved stormwater Best Management Practices to meet the General and Flooding Standards.

GENERAL STANDARDS - WATER QUALITY

The development shall provide water quality treatment for no less than 95% of the new impervious area and 80% of the developed area. The project includes the redevelopment of existing impervious area including rooftops, asphalt and gravel driveways and parking. Water quality treatment shall be provided through the use of an Underdrained Subsurface Sand Filter.

The underdrained subsurface sand filter BMP (USSF) was sized to meet the requirements set forth within the MDEP Volume III: BMPs Technical Design Manual Section 7.3. Filtration BMPs have been shown to be very effective at removing a wide range of pollutants from stormwater runoff. The stormwater runoff shall first flow into the StormTech Isolator Row which shall provide initial treatment. The stormwater shall be detained within the chambers and surrounding aggregate before flowing vertically through the sand filter layer. The treated stormwater shall then be collected within perforated pipes and released slowly by the outlet control structure at an attenuated rate.

The treatment of the impervious surface is as follows:

Table 1 - Impervious Treatment Area Table						
	Existing Impervious Area (SF)	Proposed Total Impervious Area (SF)	Proposed Impervious Area with No Treament (SF)	Proposed Impervious Area with Treament (SF)	Net change in Impervious Area (SF)	% Overall New Imp. Area Treated
USSF BMP	11,628	43603	644	42,959	31,975	134%

The treatment of the developed surface is as follows:

Table 2 - Developed Treatment Area Table			
	Developed Area (SF)	Developed Area with No Treament	% Overall Developed Area Treated **
USSF BMP	64,148	9,113	86%

As shown above the project anticipates meeting and exceeding the required treatment for new impervious surfaces and the overall developed area through the use of the underdrained subsurface sand filter BMP.

A calculation for sand filter area is necessary to meet the requirements below the surface of the USSF. As defined in the Volume III: BMPs Technical Design Manual, Chapter 7, the surface area of the filter shall be no less than the sum of 5% of the tributary impervious area and 2% of the tributary vegetated area. The filter area is calculated by the following formula:

$$[(\text{Imp. SF} \times 0.05) + (\text{Veg. SF} \times 0.02)] = \text{Filter Area (SF)}$$

Table 10 – Vegetated Underdrain Soil Filter Sizing, displays the proposed VUSF Filter sizing requirements, actual size and the percentage of required area.

Table 3 – Underdrain Subsurface Sand Filter			
	Required Filter Area (SF)	Actual Filter Area (SF)	Percentage of Required Area (%)
USSF BMP	2798	2814	101

The StormTech Isolator Row length was sized to meet and exceed the 0.2 cfs for each SC-740 based upon the one year peak flow rate. The project anticipates the use of two isolator rows which shall meet the required amount for a one year peak flow rate of 0.4 cfs.

In accordance with the Volume III: BMPs Technical Design Manual, a water quality volume of 1.0 inches times the tributary net chainge in impervious area plus 0.4 inches times the tributary disturbed area is required to be treated by the USSF. The water quality volume is calculated by the following formula:

$$\left(\frac{\text{Imp. SF x 1.0"}}{\text{12"/1'}}\right) + \left(\frac{\text{Veg. SF x 0.4"}}{\text{12"/1'}}\right) = \text{Treatment Volume (CF)}$$

The proposed water quality volume is as follows:

Table 4 - Water Quality Volume Table

	Vegetated Area (SF)	Impervious Area (SF)	Treatment Volume Required (CF)
USSF BMP	55,035	31,975	**4,499**

Once the water quality volume is known an artificial rainfall event is created within HydroCAD, to mimic a storm event which equals the water quality volume. Based upon the artificial rainfall event the depth of the water quality volume within the chamber system shall not exceed 18 inches, as required.

Provided the infiltration rates of the water quality volume through the sand filter are variable a water quality outlet is modeled to provide the required minimum 24-hour release time. This is completed by adjusting the rainfall amount in HydroCAD until the inflow volume is equal to or greater than the calculated treatment volume. The storm events are modeled as type III, 24-hour storm events in HydroCAD.

A vertical orifice is modeled in HydroCAD at the outlet control structure. The orifice diameter is sized to detain the stormwater for an approximate period of 24 hours. The orifice shall be placed at the end of the larger outfall pipe on the outlet control structure baffle to be inspected or replaced if necessary. The orifice is intended to be a PVC cap placed on the outfall pipe (no glue) with the orifice drilled into the cap eccentrically. The PVC cap can be easily inspected, removed or replaced if necessary. The orifice for the water quantity volume is then set above the peak elevation determined for the water quality volume.

FLOODING STANDARD – WATER QUANTITY

The proposed project was modeled using HydroCAD to verify that the post-development conditions do not exceed the pre-development conditions. A 24-hour SCS Type III storm distribution for the 2, 10, and 25 year storm events were used. The corresponding rainfall amounts for these storms are 3.00", 4.70", and 5.50" respectively.

Due to the numerous variables, and inherent inaccuracies with the modeling program used to calculate stormwater runoff it is custom at Acorn Engineering, Inc. to round to the nearest whole number. However due to the small size of the project the stormwater runoff shall be rounded to the nearest tenth of a cubic feet per second (cfs). Given the urban

setting, and steep slopes, a 5 minute time of concentration (T_c) was applied to each subcatchment for both the pre and post-development conditions.

Pre-development Calculations

Given the prior agreement with the City to outlet the development's stormwater within Walnut Street the pre-development condition was modeled as one subcatchment to determine the net impact of the development.

- Subcatchment 1 – The subcatchment area is defined to the North, West and South by the property line and to West by the extents of the area tributary to the development.

A Pre-development Watershed Map developed for this project can be viewed in Attachment A, and a copy of the HydroCAD calculations is included within Attachment D, or this report. Peak flow rates for the storm events are as follows:

Table 5 – Pre-Development Peak Stormwater Flows			
Drainage Area	**2 – Year Storm Event (cfs)**	**10 – Year Storm Event (cfs)**	**25 – Year Storm Event (cfs)**
POI #1	0.6	2.7	4.0

Post-development Calculations:

The one predevelopment subcatchment was broken into two separate subcatchments for the post-development condition.

- Subcatchment 1 – This is comprised of the offsite and project development area tributary to the USSF which outlets to Walnut Street.
- Subcatchment 2 – This subcatchment is characterized as the landscaped area downhill of the driveway and proposed sidewalk to East Cove St.

The post development calculations include changes to the land use, and the compensation provided by the detention facility. The following table represents comparison of predevelopment and post-development condition peak runoff rates for the proposed development and tributary area.

Table 6 – Comparison of Peak Flows						
Drainage Area	**2 – Year Storm Event (cfs)**		**10 – Year Storm Event (cfs)**		**25 – Year Storm Event (cfs)**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
POI #1	0.6	0.6	2.7	2.7	4.0	4.0

As shown in Table 6 the net impact of the post development peak flows shall remain at or below the predevelopment levels. A Post-development Watershed Map developed for this project can be viewed in Attachment A, and a copy of the HydroCAD calculations is included within Attachment D, of this report.

The 100-year storm event was modeled to determine whether a 12" outlet would restrict the conveyance of stormwater. The results determine that the 12" outlet can withhold the 100-year peak flow of 5.7 cfs and has the potential to outlet 10.2 cfs of stormwater flow. Given the relative small peak flows the rational method was not utilized to size the storm drains.

Down Gradient Property Owners:

The post development (proposed) peak stormwater surface flows tributary to the down gradient property owners shall remain below the predevelopment (existing) levels. This is a result of the project's LID techniques, subsurface detention, terracing the development, extensive landscaping and diverting a portion of the tributary area.

SOILS

Onsite soil information includes the following:

- Summit Geoengineering Services – Preliminary Geotechnical Report, dated July 2013.
- Summit Geoengineering Services – Soil Boring Logs, Dated September 26, 2013.
- Mark Hampton Associates, Inc. – Hydrological Classification of Soils Letter, dated August 25, 2013.

Given the soils information, listed above, no onsite wastewater is proposed, deep fills/cuts the applicant does not intend to perform a more intense hydric soil boundary delineation because of the waiver requirements set forth in the City of Portland Technical Manual – Section 7 – Soil Survey, Rev. 6/17/12 are met.

The area within and surrounding the project includes soils types listed in the table below. The susceptibility of soils to erosion is indicated on a relative "K" scale of values over a range of 0.02 to 0.69. Higher "K" values indicate more erodible soils.

Table 3 - "K" Value

Soils Type	Subsurface	Substratum
Hinckley	.17	.17

The soil "K" values for the soils, listed above, show a low susceptibility to erosion. The site's susceptibility to erosion is from the Soil Conservation Service Medium Intensity Soil Survey for Cumberland County. Although soil "K" values for the soils show a low susceptibility to erosion, implementation of the proposed Erosion & Sedimentation Measures by the contractor will be of the utmost importance, given the long sustained slopes.

Conclusion

The proposed development was designed to meet the requirements implemented by the MDEP under the Stormwater Management Statute (38 M.R.S.A. § 420-D) as well as the City of Portland Technical Manual – Section 5 – Portland Stormwater Management Standards. As a result the design of the proposed development and stormwater system does not anticipate to create erosion, drainage or runoff problems either in the development or with respect to adjoining properties.

Attachments

Attachment A: Pre Development Watershed Map
Attachment B: Post Development Watershed Map
Attachment C: Mark Hampton Associates, Inc. – Hydrological Classification of Soils Letter, dated August 25, 2013
Attachment D: HydroCAD Calculations
Attachment E: Stormwater Operation and Maintenance Plan

Attachment A

Predevelopment Watershed Map

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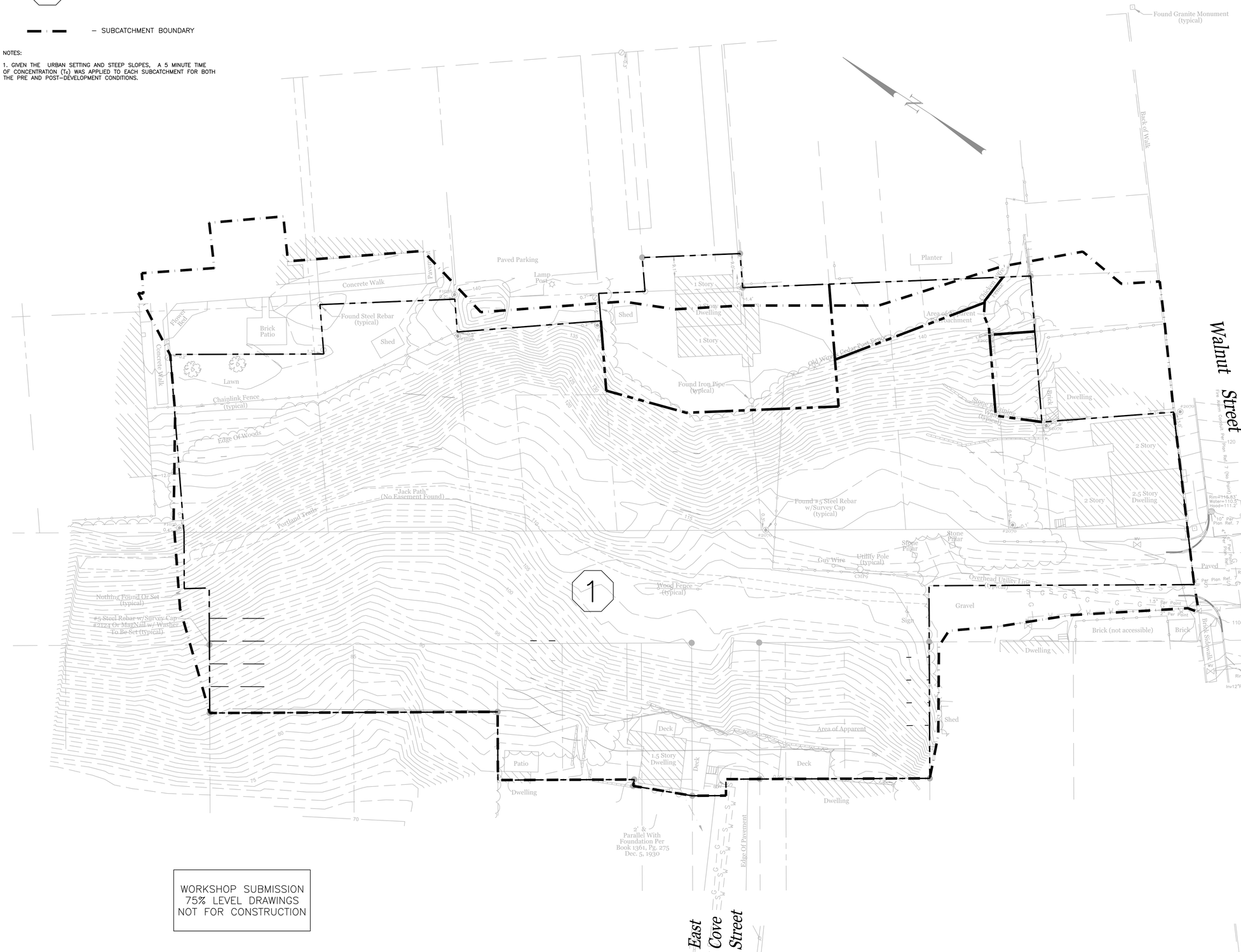
LEGEND

1 – SUBCATCHMENT

– SUBCATCHMENT BOUNDARY

NOTES:

1. GIVEN THE URBAN SETTING AND STEEP SLOPES, A 5 MINUTE TIME OF CONCENTRATION (T_c) WAS APPLIED TO EACH SUBCATCHMENT FOR BOTH THE PRE AND POST-DEVELOPMENT CONDITIONS.



WORKSHOP SUBMISSION
75% LEVEL DRAWINGS
NOT FOR CONSTRUCTION

ISSUED FOR	BY DATE
WORKSHOP #2	WHS 11/12/13

REVISION	REV. DATE

DRAWING NAME: PRE-DEVELOPMENT WATERSHED MAP

PROJECT NAME: MUNJOY HEIGHTS

CLIENT: REDFERN PROPERTIES, LLC
P.O. BOX 8816, PORTLAND, MAINE 04104

ACORN ENGINEERING, INC.
ACORN ENGINEERING, INC.
P.O. BOX 3372 PORTLAND, MAINE 04104
(207) 772-2655

FILE:	1047_CIVIL
DATE:	9/23/13
JN:	1047
SCALE:	1"=20'
DESIGN BY:	WHS
DRAWN BY:	ZRJ
CHECKED BY:	WHS

STATE OF MAINE
WILLIAM H. SAVAGE
No. 11419
11-12-13
REGISTERED PROFESSIONAL ENGINEER

DRAWING NO.
PRE

Attachment B

Post Development Watershed Map

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LEGEND

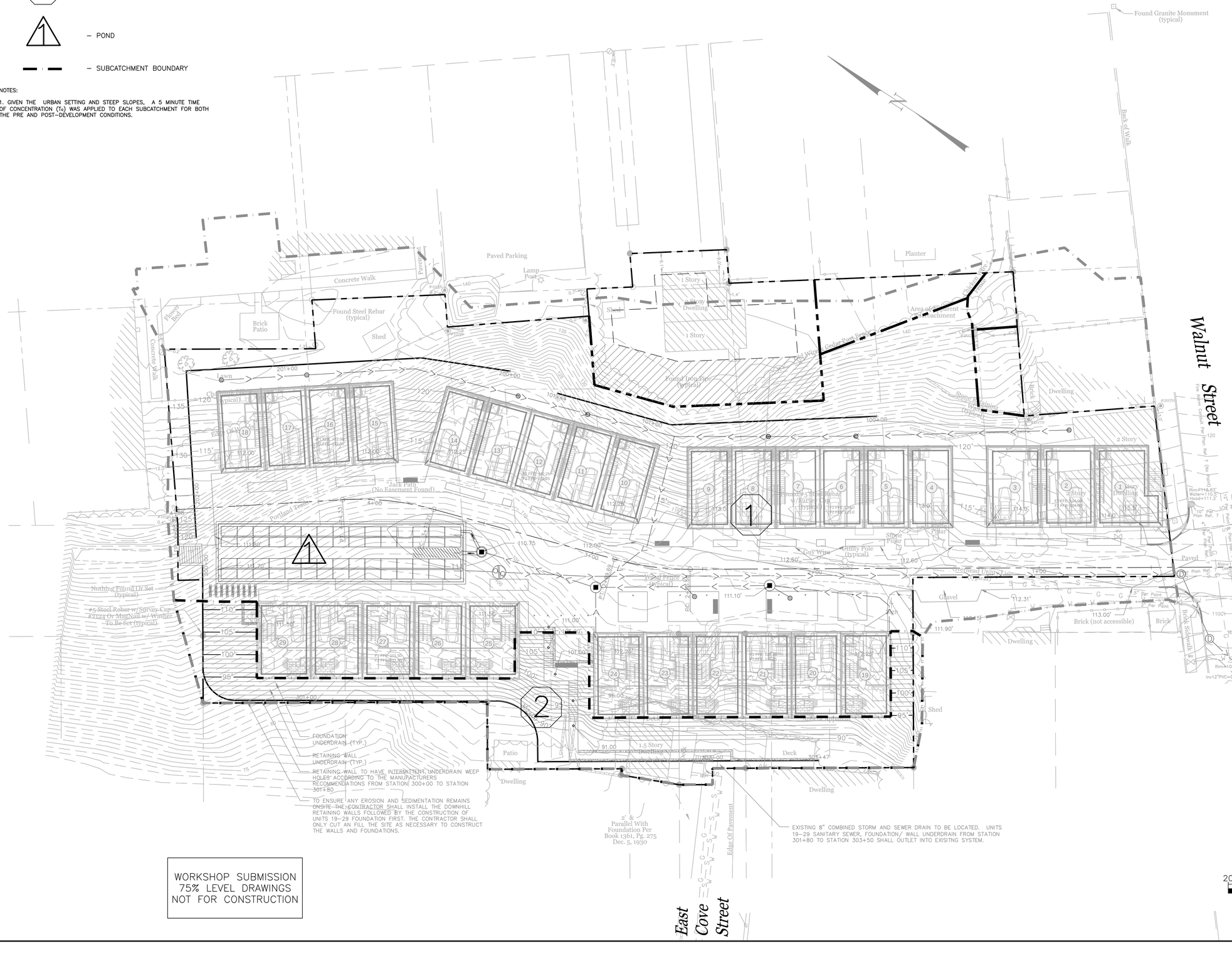
1 – SUBCATCHMENT

1 – POND

– SUBCATCHMENT BOUNDARY

NOTES:

1. GIVEN THE URBAN SETTING AND STEEP SLOPES, A 5 MINUTE TIME OF CONCENTRATION (Tc) WAS APPLIED TO EACH SUBCATCHMENT FOR BOTH THE PRE AND POST-DEVELOPMENT CONDITIONS.



WORKSHOP SUBMISSION
75% LEVEL DRAWINGS
NOT FOR CONSTRUCTION

ISSUED FOR	BY: DATE
WORKSHOP #2	WHS 11/12/13
REVISION	REV. DATE

DRAWING NAME: POST-DEVELOPMENT WATER QUALITY PLAN

PROJECT NAME: MUNJOY HEIGHTS

CLIENT: REDFERN PROPERTIES, LLC
P.O. BOX 8816, PORTLAND, MAINE 04104

ACORN ENGINEERING, INC.
ACORN ENGINEERING, INC.
P.O. BOX 3372 PORTLAND, MAINE 04104
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FILE:	1047_CIVIL
DATE:	9/23/13
JN:	1047
SCALE:	1"=20'
DESIGN BY:	WHS
DRAWN BY:	ZRJ
CHECKED BY:	WHS

STATE OF MAINE
WILLIAM H. SAVAGE
No. 11410
11-12-13
REGISTERED PROFESSIONAL ENGINEER

DRAWING NO.
POST

Attachment C

Mark Hampton Associates, Inc. – Hydrological Classification of Soils Letter

MARK HAMPTON ASSOCIATES, INC.

SOIL EVALUATION • WETLAND DELINEATIONS • SOIL SURVEYS • WETLAND PERMITTING

3539

August 25, 2013

Mr. Will Savage
Acorn Engineering, Inc.
P. O. Box 3372
Portland, ME 04104

Re: Munjoy Heights, Hydrological Classification of Soils, Portland, ME

Dear Will,

Based on my site walk and review of the geo report and review of the SCS hydrological soil classification I would place the majority of soils found on site into either a Class B or Class C soil grouping. Class A soils are all soils that have no restrictive layer within 48 inches of the soil surface and has a saturated hydraulic conductivity rate of at least 1.5 inches per minute in all horizons. Only Test pits 2 and 5 had deep sections of the marine near shore unit. All the other test pits show a shallow band of this unit overlaying denser soil units or either till or glacial marine.

Based upon the geo report, the near shore and marine units are potentially limiting in saturated hydraulic conductivity and as such, places these soils into either the B or C hydrologic soil groupings. These units are described as either compact or stiff, referring to the density of the material. Based on the soil log descriptions the and the depths of the testpits, the coarse textures soils are dense in place, otherwise it would have been difficult to dig 7-14 ft deep. There was no mention of sidewall caving. Additional testing would be needed to differentiate the areas of Class B and Class C soils.

Mark Hampton C.S.S., L.S.E.
Certified Soil Scientist #263
Licensed Site Evaluator #216

P.O. BOX 1931 • PORTLAND, ME 04104-1931 • 207-756-2900 • mhampto1@maine.rr.com

Quality services that meet your deadline

Attachment D

HydroCAD Calculation

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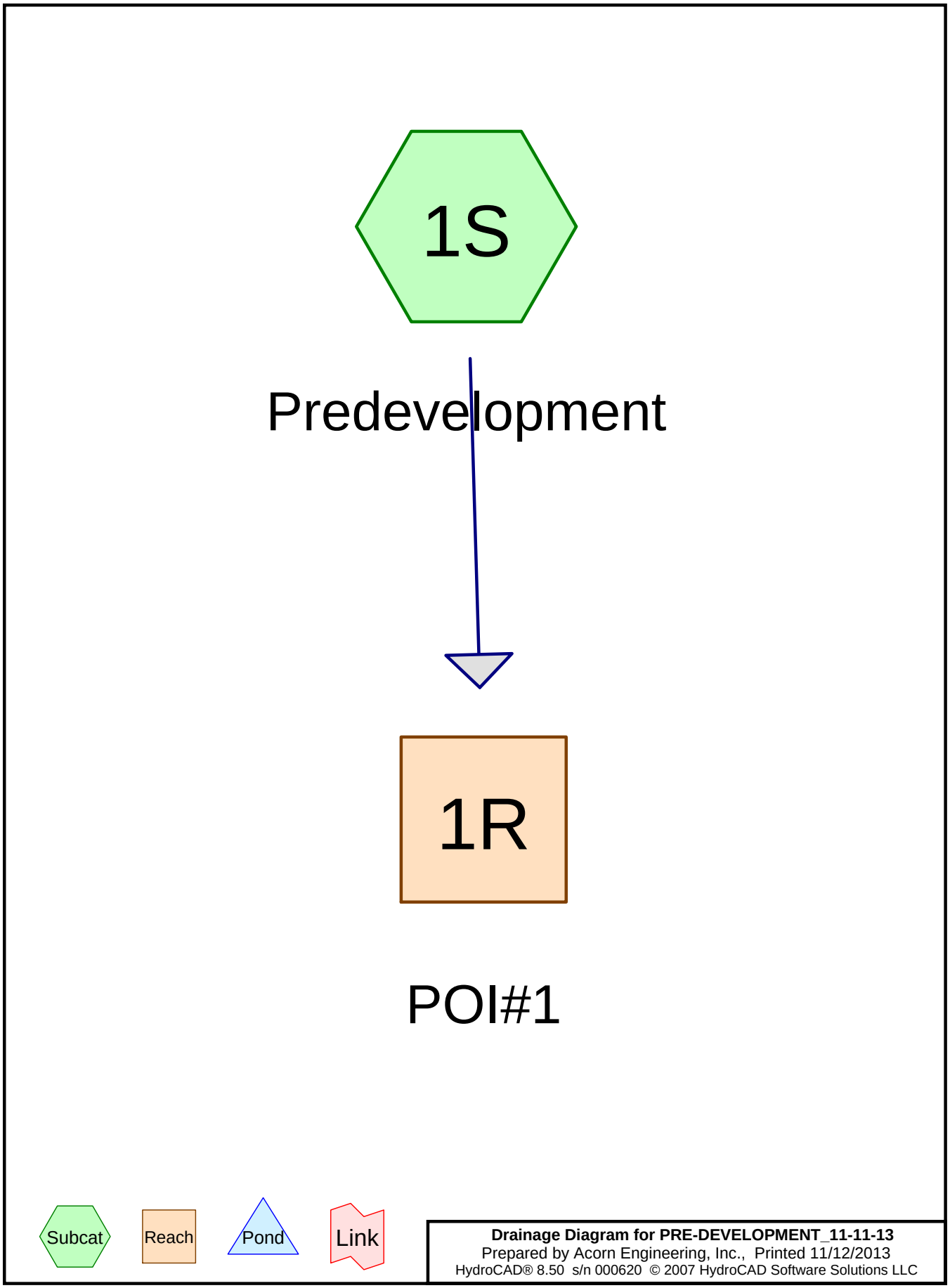


Drainage Diagram for PRE-DEVELOPMENT_11-11-13
Prepared by Acorn Engineering, Inc., Printed 11/12/2013

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.404	55	Woods, Good, HSG B (1S)
0.286	61	>75% Grass cover, Good, HSG B (1S)
0.058	96	Gravel (1S)
0.164	98	Buildings (1S)
0.016	98	Pavement (1S)
0.029	98	Sidewalk (1S)

Soil Listing (all nodes)

Area (acres)	Soil Goup	Subcatchment Numbers
0.000	HSG A	
1.691	HSG B	1S
0.000	HSG C	
0.000	HSG D	
0.267	Other	1S

Summary for Subcatchment 1S: Predevelopment

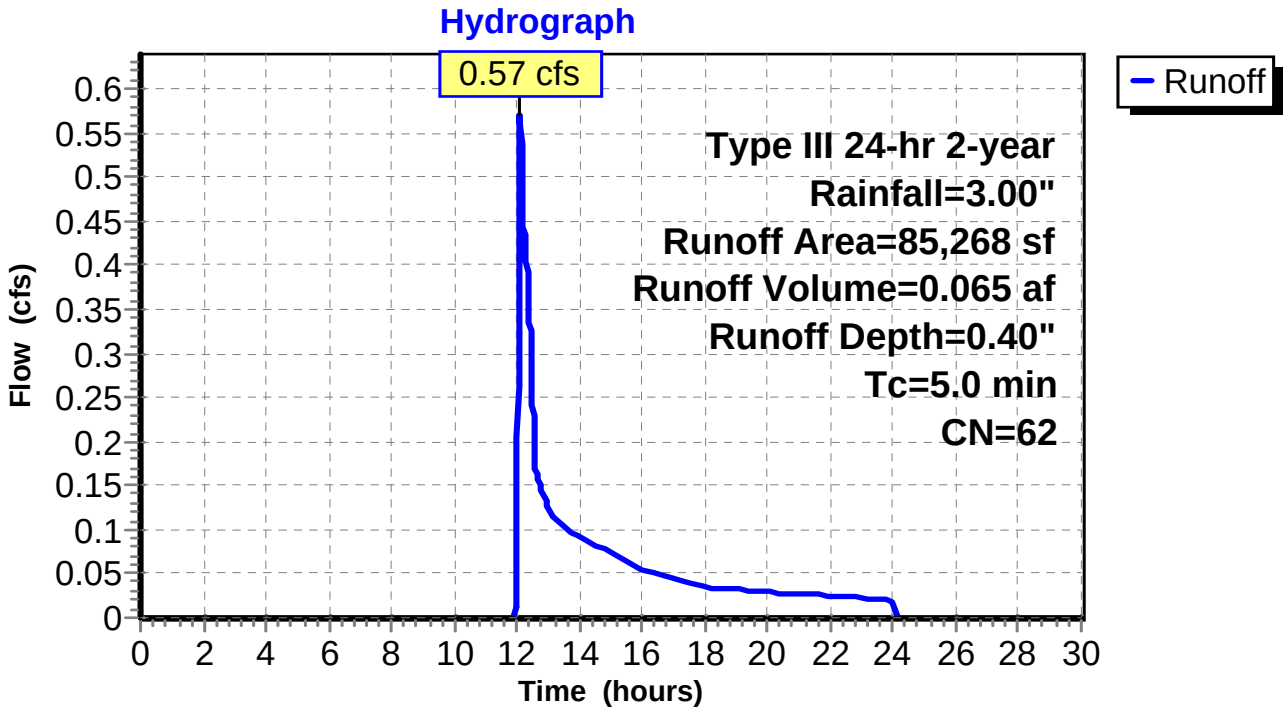
Runoff = 0.57 cfs @ 12.11 hrs, Volume= 0.065 af, Depth= 0.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-year Rainfall=3.00"

	Area (sf)	CN	Description
	61,172	55	Woods, Good, HSG B
	12,468	61	>75% Grass cover, Good, HSG B
*	1,284	98	Sidewalk
*	7,148	98	Buildings
*	689	98	Pavement
*	2,507	96	Gravel
	85,268	62	Weighted Average
	76,147		Pervious Area
	9,121		Impervious Area

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

Subcatchment 1S: Predevelopment

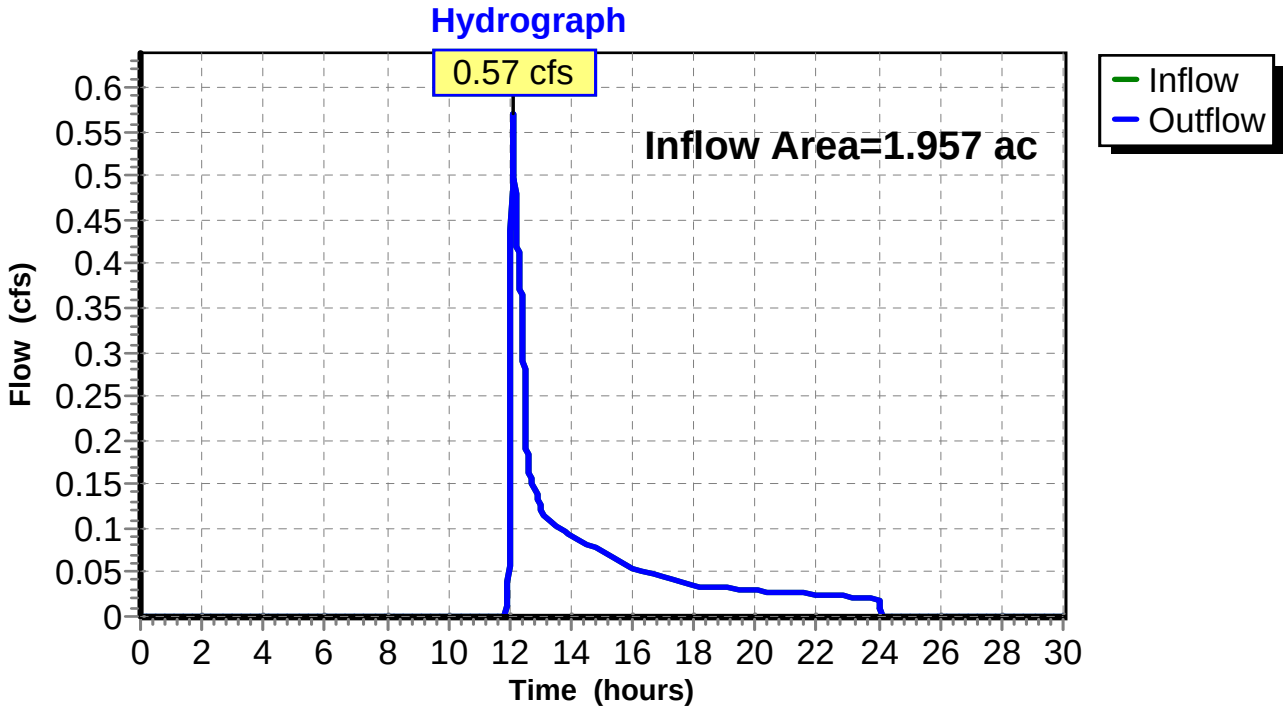


Summary for Reach 1R: POI#1

Inflow Area = 1.957 ac, 10.70% Impervious, Inflow Depth = 0.40" for 2-year event
Inflow = 0.57 cfs @ 12.11 hrs, Volume= 0.065 af
Outflow = 0.57 cfs @ 12.11 hrs, Volume= 0.065 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Reach 1R: POI#1



Summary for Subcatchment 1S: Predevelopment

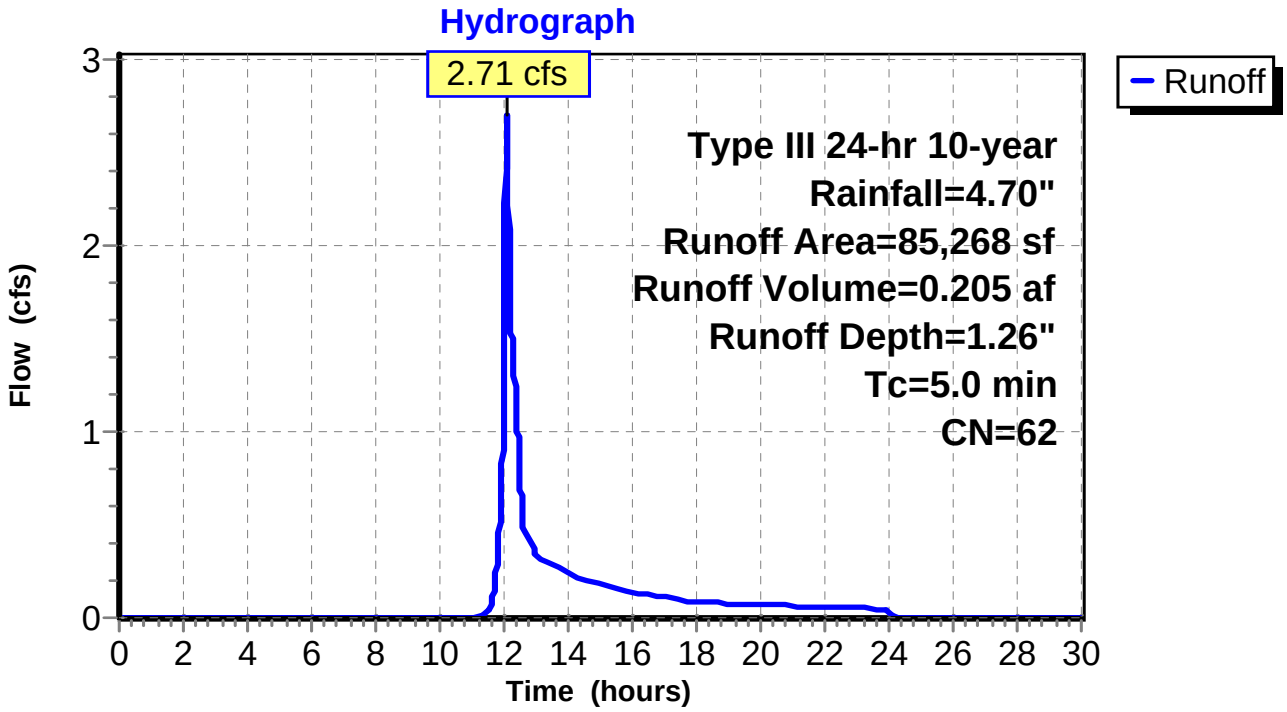
Runoff = 2.71 cfs @ 12.08 hrs, Volume= 0.205 af, Depth= 1.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-year Rainfall=4.70"

	Area (sf)	CN	Description
	61,172	55	Woods, Good, HSG B
	12,468	61	>75% Grass cover, Good, HSG B
*	1,284	98	Sidewalk
*	7,148	98	Buildings
*	689	98	Pavement
*	2,507	96	Gravel
	85,268	62	Weighted Average
	76,147		Pervious Area
	9,121		Impervious Area

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

Subcatchment 1S: Predevelopment

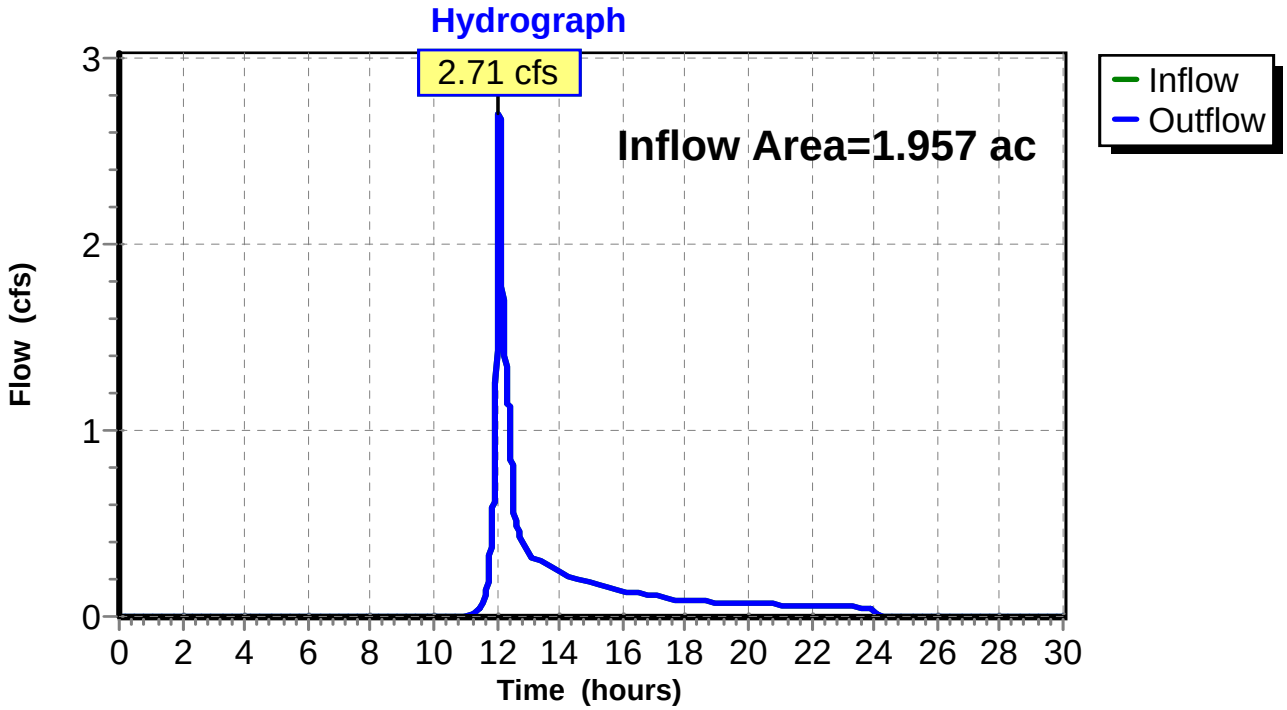


Summary for Reach 1R: POI#1

Inflow Area = 1.957 ac, 10.70% Impervious, Inflow Depth = 1.26" for 10-year event
Inflow = 2.71 cfs @ 12.08 hrs, Volume= 0.205 af
Outflow = 2.71 cfs @ 12.08 hrs, Volume= 0.205 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Reach 1R: POI#1



Summary for Subcatchment 1S: Predevelopment

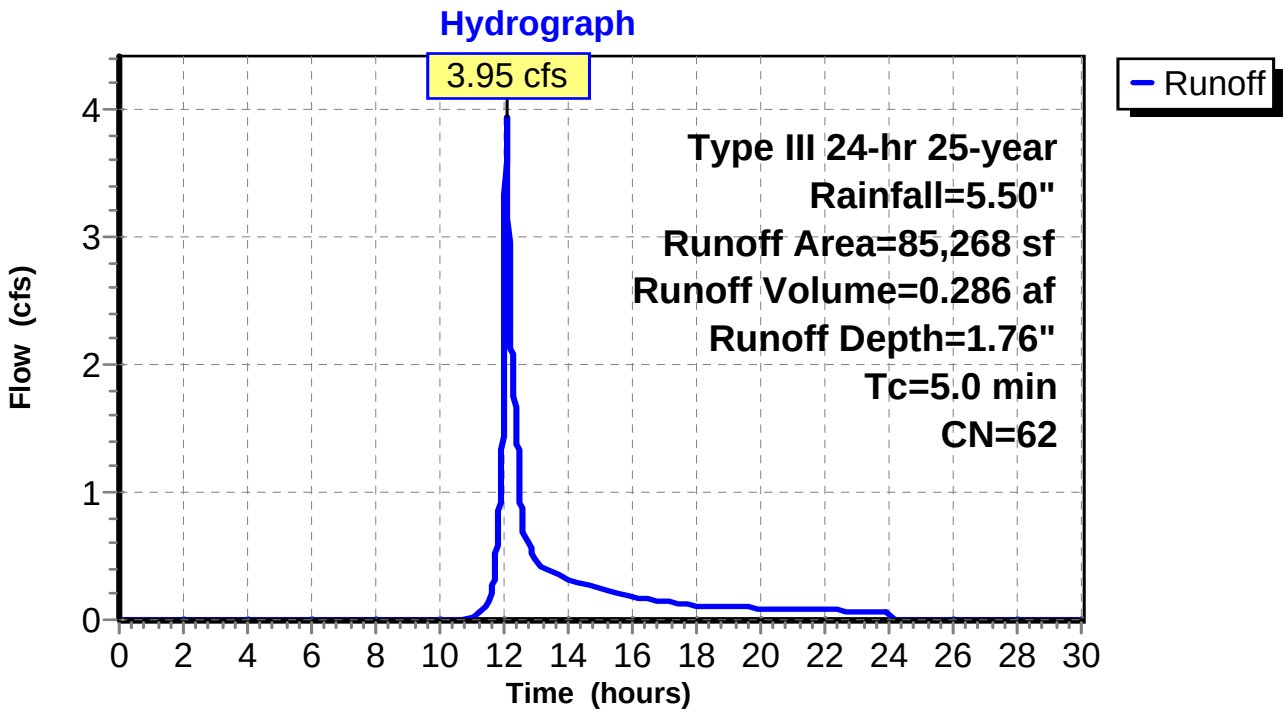
Runoff = 3.95 cfs @ 12.08 hrs, Volume= 0.286 af, Depth= 1.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	61,172	55	Woods, Good, HSG B
	12,468	61	>75% Grass cover, Good, HSG B
*	1,284	98	Sidewalk
*	7,148	98	Buildings
*	689	98	Pavement
*	2,507	96	Gravel
	85,268	62	Weighted Average
	76,147		Pervious Area
	9,121		Impervious Area

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

Subcatchment 1S: Predevelopment

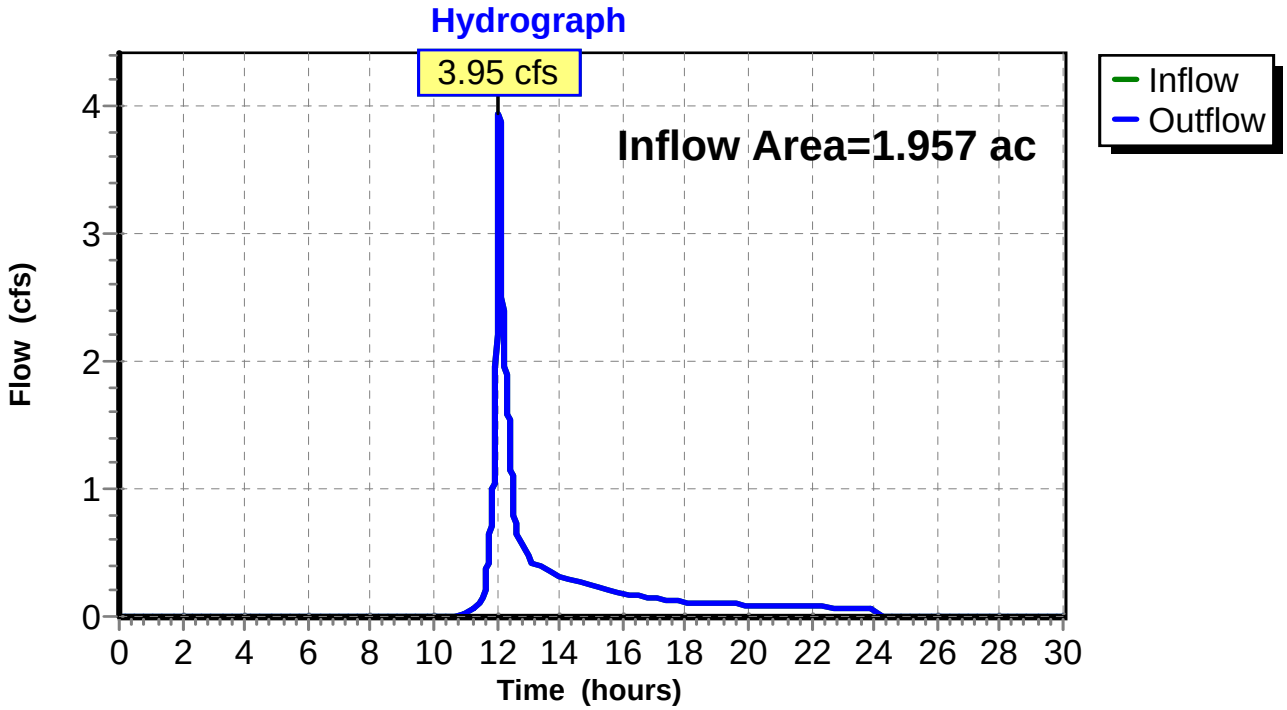


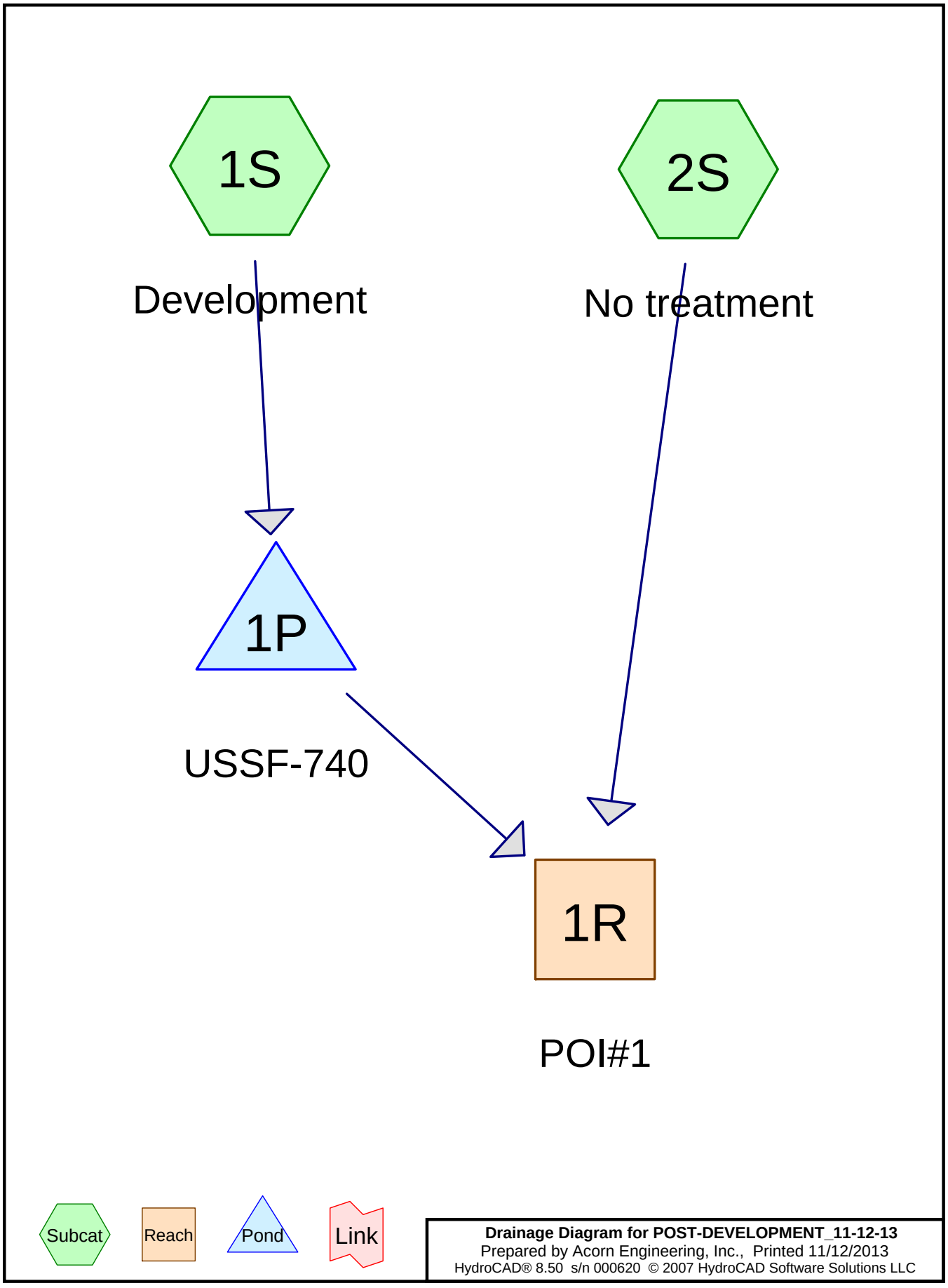
Summary for Reach 1R: POI#1

Inflow Area = 1.957 ac, 10.70% Impervious, Inflow Depth = 1.76" for 25-year event
Inflow = 3.95 cfs @ 12.08 hrs, Volume= 0.286 af
Outflow = 3.95 cfs @ 12.08 hrs, Volume= 0.286 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Reach 1R: POI#1





Drainage Diagram for POST-DEVELOPMENT_11-12-13
Prepared by Acorn Engineering, Inc., Printed 11/12/2013

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.100	55	Woods, Good, HSG B (1S)
0.857	61	>75% Grass cover, Good, HSG B (1S,2S)
0.093	98	Existing Buildings (1S)
0.029	98	Existing Sidewalk (1S)
0.356	98	Pavement (1S)
0.508	98	Proposed Buildings (1S)
0.015	98	Sidewalk to East Cove (2S)

Soil Listing (all nodes)

Area (acres)	Soil Goup	Subcatchment Numbers
0.000	HSG A	
0.956	HSG B	1S, 2S
0.000	HSG C	
0.000	HSG D	
1.001	Other	1S, 2S

Summary for Subcatchment 1S: Development

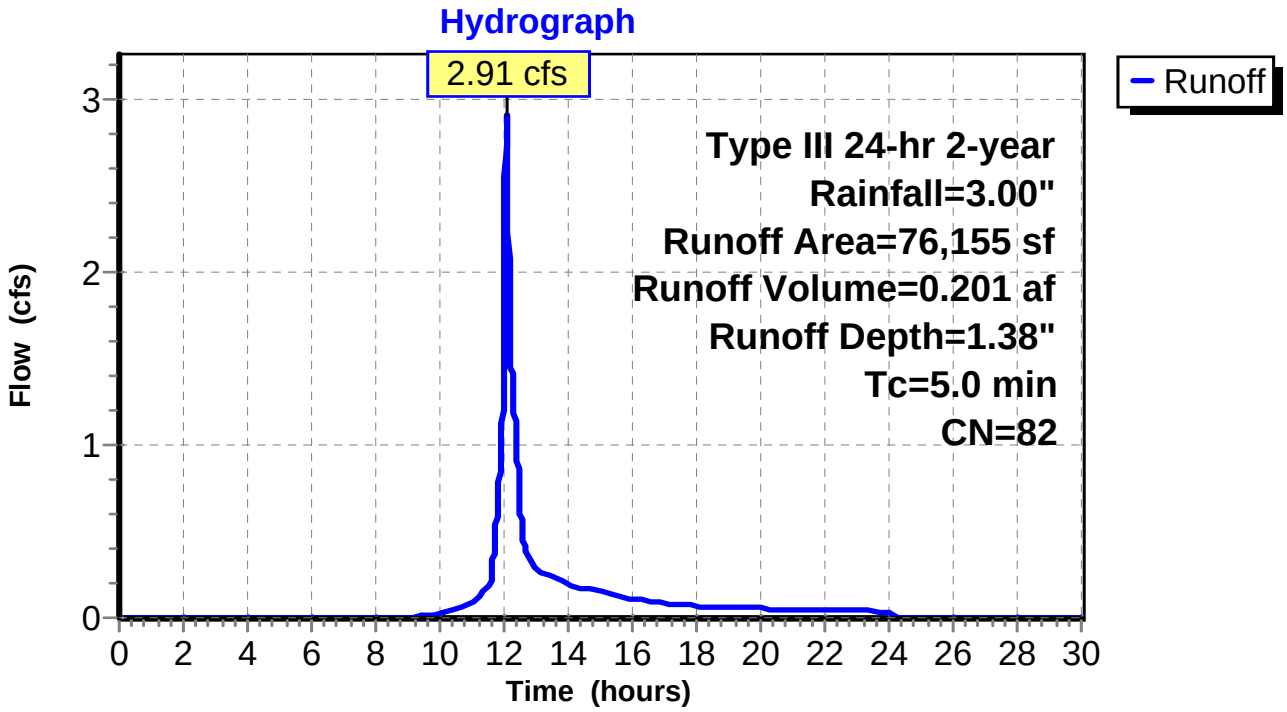
Runoff = 2.91 cfs @ 12.08 hrs, Volume= 0.201 af, Depth= 1.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-year Rainfall=3.00"

	Area (sf)	CN	Description
	4,348	55	Woods, Good, HSG B
	28,848	61	>75% Grass cover, Good, HSG B
*	1,284	98	Existing Sidewalk
*	22,132	98	Proposed Buildings
*	4,043	98	Existing Buildings
*	15,500	98	Pavement
	76,155	82	Weighted Average
	33,196		Pervious Area
	42,959		Impervious Area

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

Subcatchment 1S: Development



Summary for Subcatchment 2S: No treatment

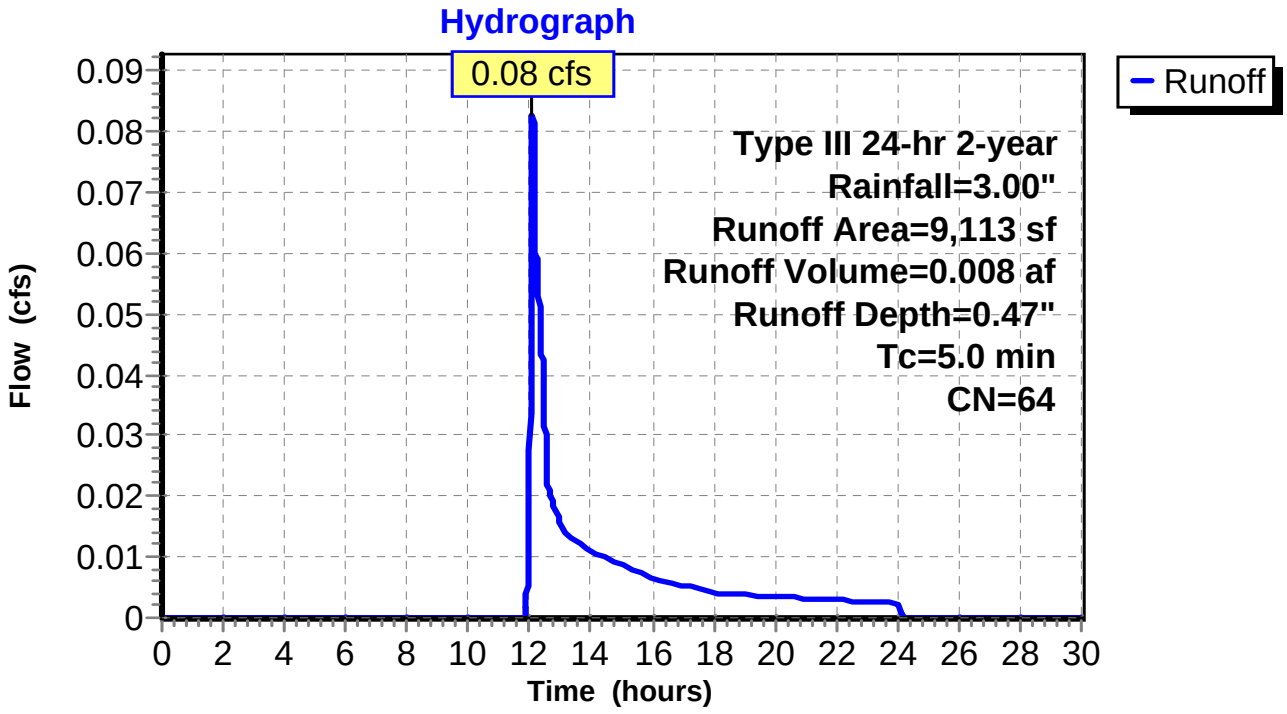
Runoff = 0.08 cfs @ 12.10 hrs, Volume= 0.008 af, Depth= 0.47"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-year Rainfall=3.00"

	Area (sf)	CN	Description
	8,469	61	>75% Grass cover, Good, HSG B
*	644	98	Sidewalk to East Cove
	9,113	64	Weighted Average
	8,469		Pervious Area
	644		Impervious Area

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

Subcatchment 2S: No treatment

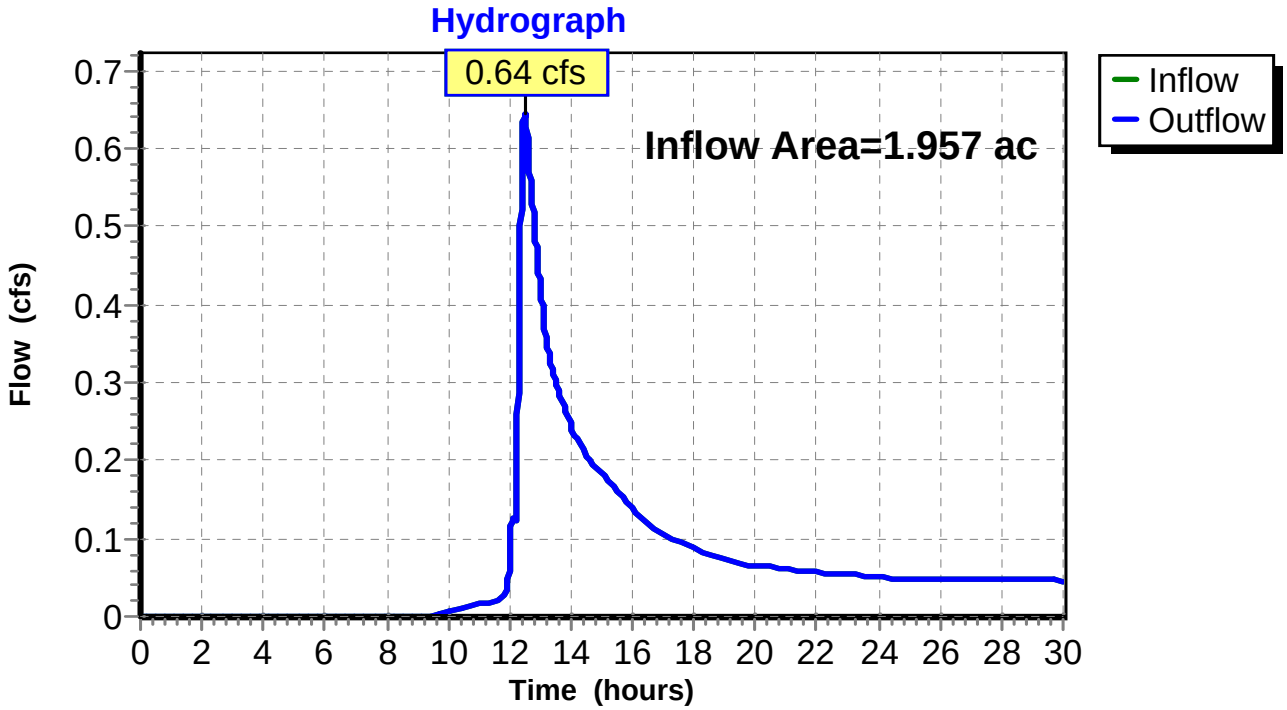


Summary for Reach 1R: POI#1

Inflow Area = 1.957 ac, 51.14% Impervious, Inflow Depth > 1.02" for 2-year event
Inflow = 0.64 cfs @ 12.50 hrs, Volume= 0.166 af
Outflow = 0.64 cfs @ 12.50 hrs, Volume= 0.166 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Reach 1R: POI#1



Summary for Pond 1P: USSF-740

Inflow Area = 1.748 ac, 56.41% Impervious, Inflow Depth = 1.38" for 2-year event
Inflow = 2.91 cfs @ 12.08 hrs, Volume= 0.201 af
Outflow = 0.61 cfs @ 12.52 hrs, Volume= 0.158 af, Atten= 79%, Lag= 26.3 min
Primary = 0.61 cfs @ 12.52 hrs, Volume= 0.158 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 106.72' @ 12.52 hrs Surf.Area= 8,456 sf Storage= 3,819 cf

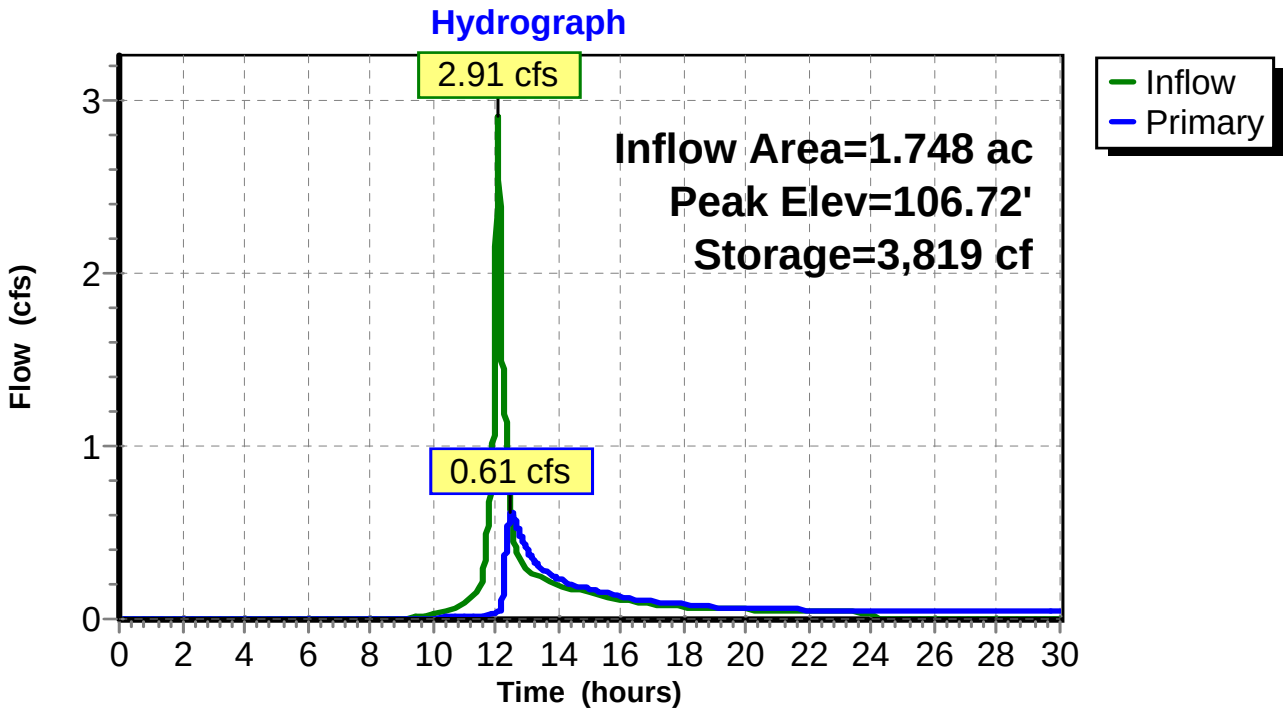
Plug-Flow detention time= 279.0 min calculated for 0.158 af (79% of inflow)
Center-of-Mass det. time= 197.0 min (1,035.5 - 838.5)

Volume	Invert	Avail.Storage	Storage Description
#1	105.75'	53 cf	**4.00'D x 4.25'H Vertical Cone/Cylinder**
#2	105.50'	2,580 cf	**25.75'W x 109.30'L x 3.50'H Crushed Stone** 9,851 cf Overall - 3,400 cf Embedded = 6,451 cf x 40.0% Voids
#3	105.75'	3,400 cf	**44.6"W x 30.0"H x 7.12'L StormTech SC-740** x 74 Inside #2
#4	104.00'	211 cf	**25.75'W x 109.30'L x 1.50'H Sand** 4,222 cf Overall x 5.0% Voids
#5	103.00'	1,118 cf	**25.75'W x 109.30'L x 1.00'H Crushed Stone Underdrain** 2,814 cf Overall - 19 cf Embedded = 2,795 cf x 40.0% Voids
#6	103.33'	19 cf	**4.0"D x 109.00'L Underdrains** x 2 Inside #5
		7,382 cf	Total Available Storage

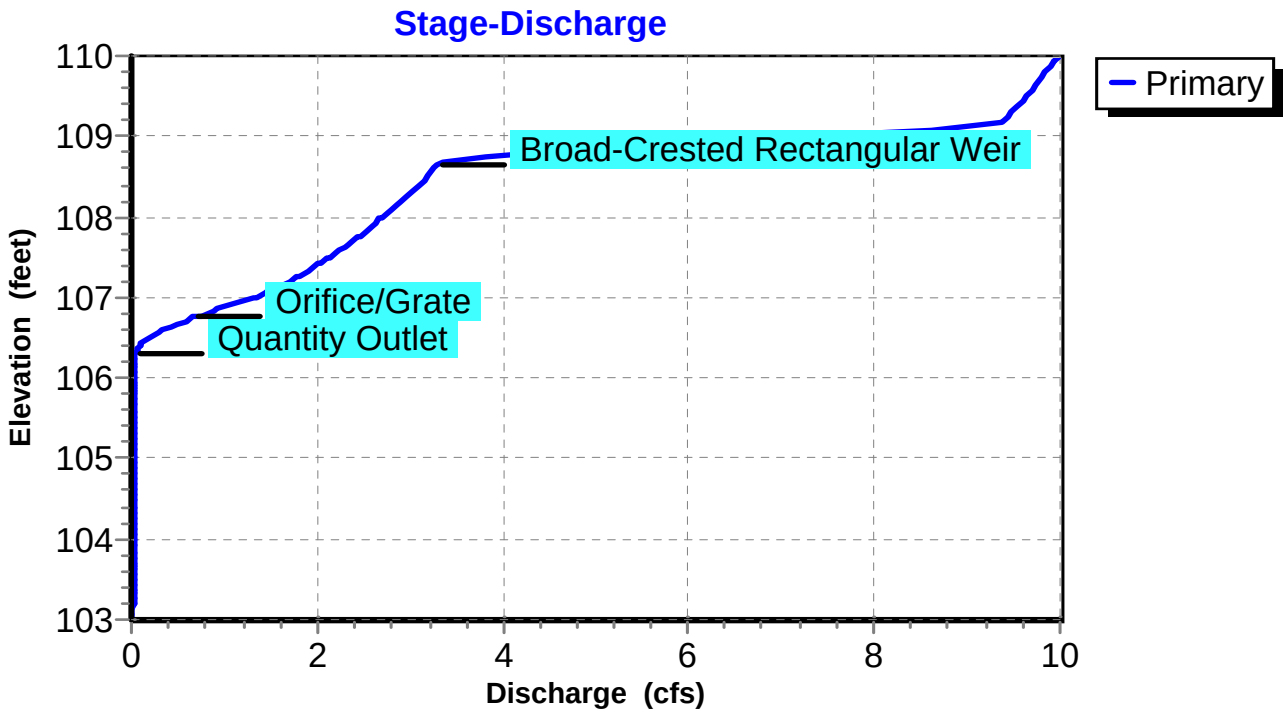
Device	Routing	Invert	Outlet Devices
#1	Primary	102.50'	**12.0" Vert. 12" Outlet to the Walnut St** C= 0.600
#2	Device 1	102.75'	**1.0" Vert. Quality Outlet** C= 0.600
#3	Device 1	106.30'	**8.8" Vert. Quantity Outlet** C= 0.600
#4	Device 1	106.75'	**3.3" Vert. Orifice/Grate** C= 0.600
#5	Device 1	108.65'	**6.0' long x 0.7' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 Coef. (English) 2.76 2.82 2.93 3.09 3.18 3.22 3.27 3.30 3.32 3.31 3.32

Primary OutFlow Max=0.61 cfs @ 12.52 hrs HW=106.72' (Free Discharge)
└**1=12" Outlet to the Walnut St** (Passes 0.61 cfs of 7.30 cfs potential flow)
  ├**2=Quality Outlet** (Orifice Controls 0.05 cfs @ 9.55 fps)
  ├**3=Quantity Outlet** (Orifice Controls 0.56 cfs @ 2.22 fps)
  ├**4=Orifice/Grate** (Controls 0.00 cfs)
  └**5=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

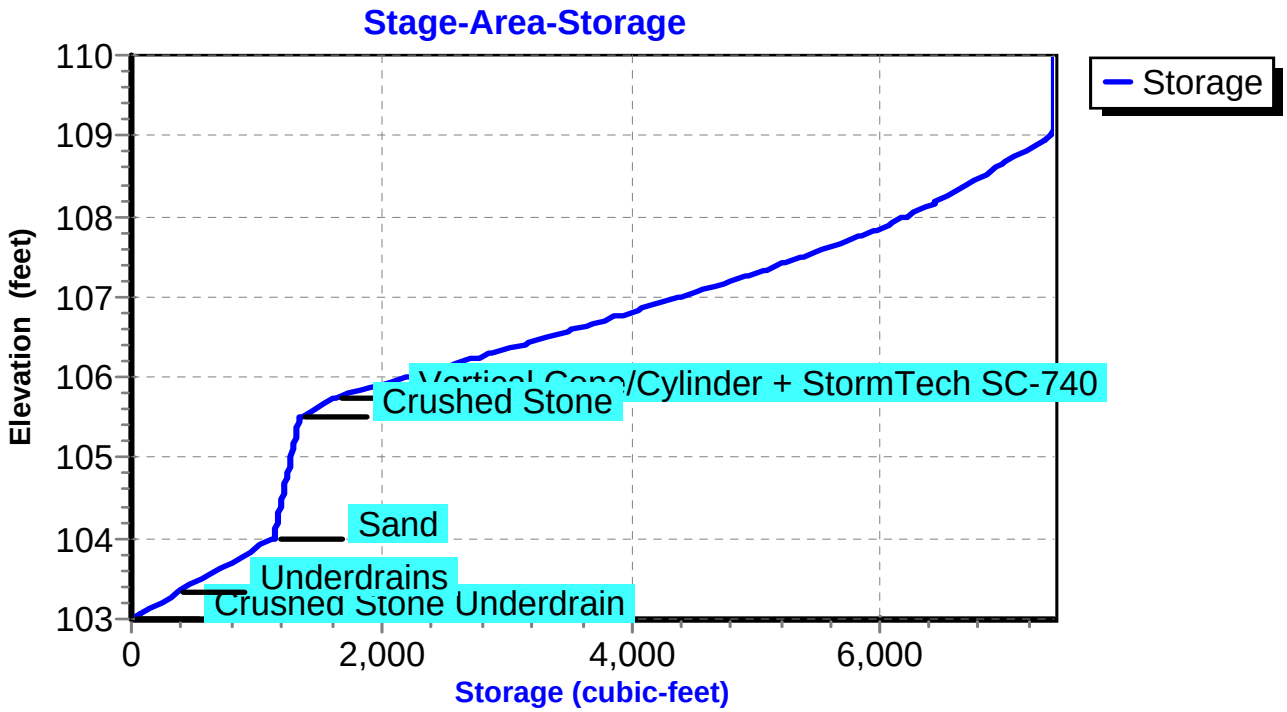
Pond 1P: USSF-740



Pond 1P: USSF-740



Pond 1P: USSF-740



Summary for Subcatchment 1S: Development

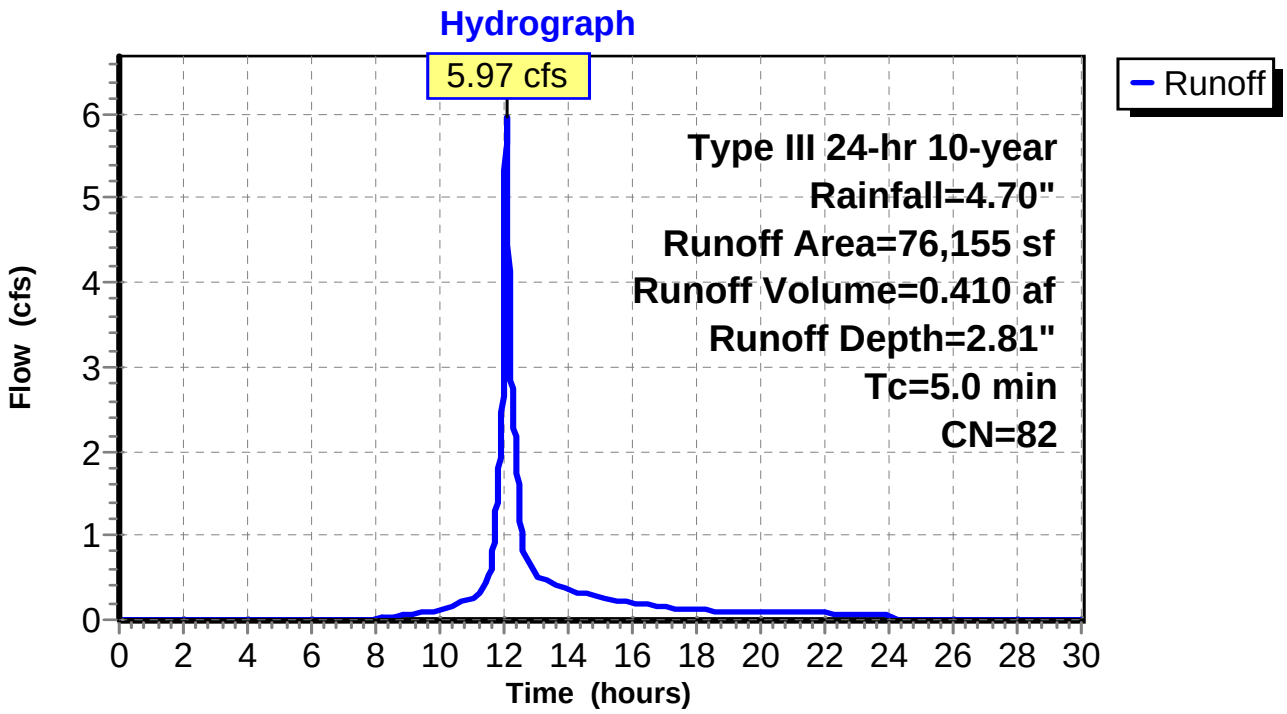
Runoff = 5.97 cfs @ 12.07 hrs, Volume= 0.410 af, Depth= 2.81"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-year Rainfall=4.70"

	Area (sf)	CN	Description
	4,348	55	Woods, Good, HSG B
	28,848	61	>75% Grass cover, Good, HSG B
*	1,284	98	Existing Sidewalk
*	22,132	98	Proposed Buildings
*	4,043	98	Existing Buildings
*	15,500	98	Pavement
	76,155	82	Weighted Average
	33,196		Pervious Area
	42,959		Impervious Area

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

Subcatchment 1S: Development



Summary for Subcatchment 2S: No treatment

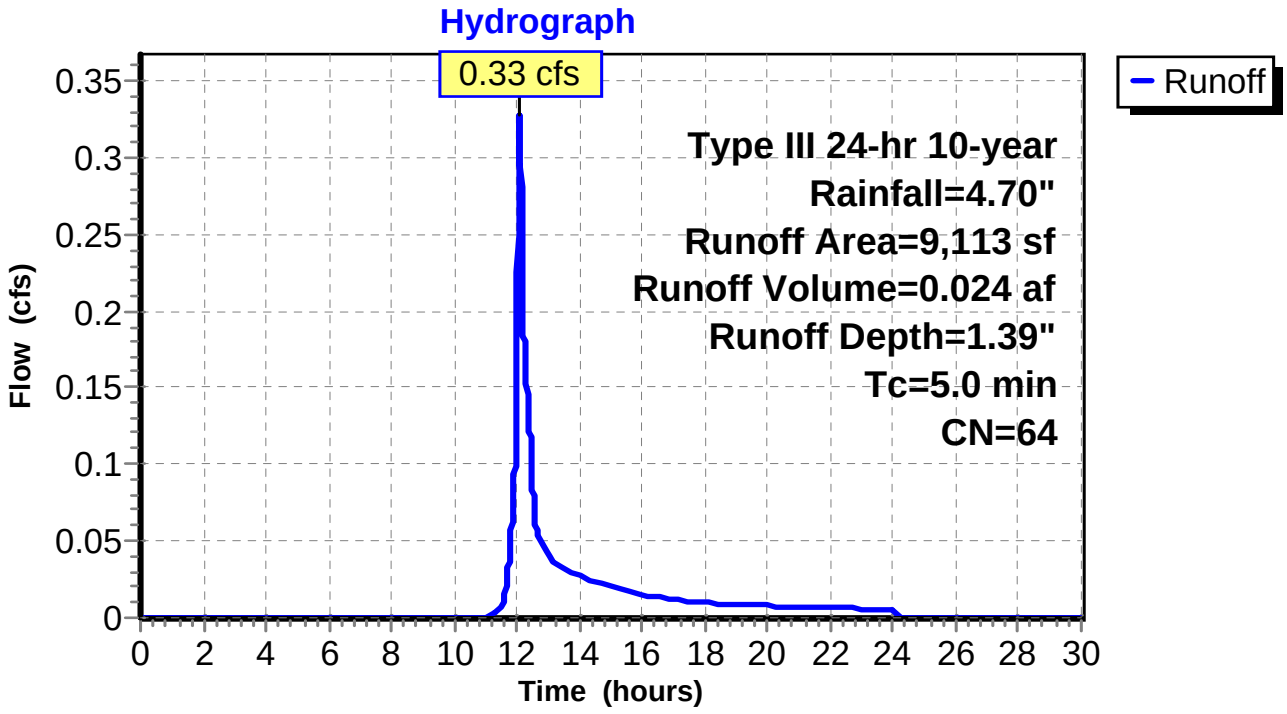
Runoff = 0.33 cfs @ 12.08 hrs, Volume= 0.024 af, Depth= 1.39"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-year Rainfall=4.70"

	Area (sf)	CN	Description
	8,469	61	>75% Grass cover, Good, HSG B
*	644	98	Sidewalk to East Cove
	9,113	64	Weighted Average
	8,469		Pervious Area
	644		Impervious Area

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

Subcatchment 2S: No treatment

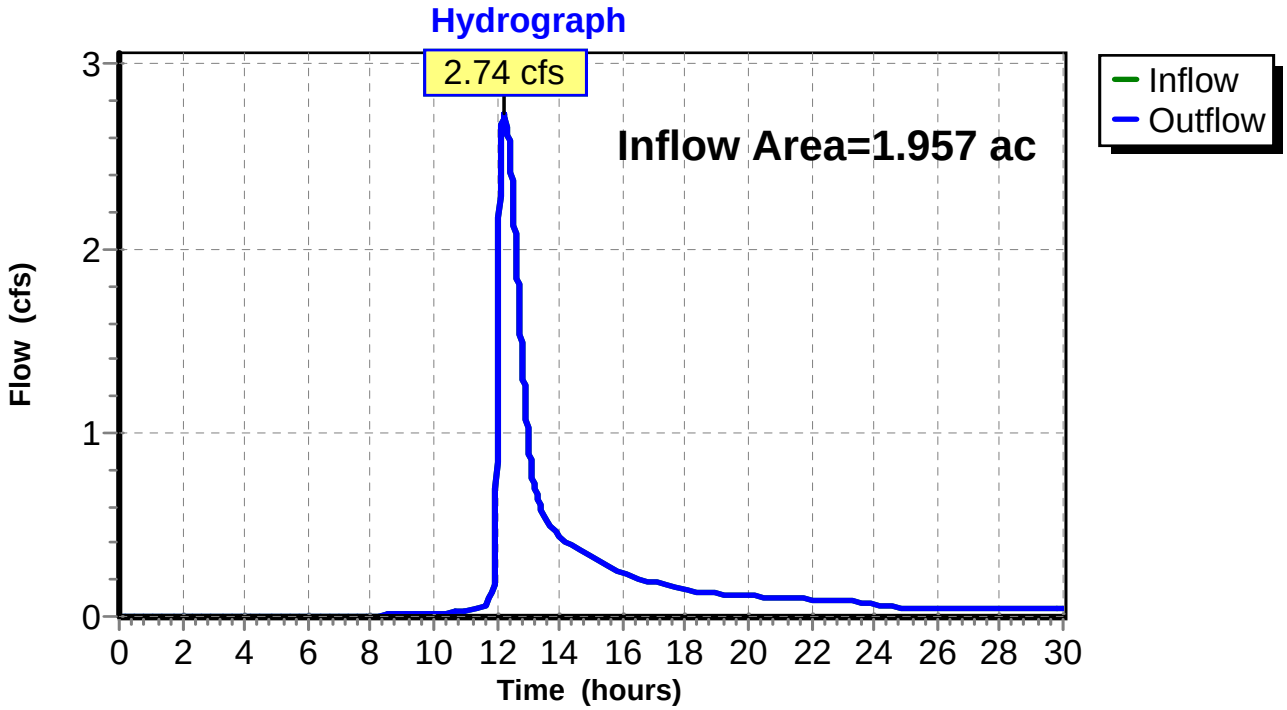


Summary for Reach 1R: POI#1

Inflow Area = 1.957 ac, 51.14% Impervious, Inflow Depth > 2.38" for 10-year event
Inflow = 2.74 cfs @ 12.25 hrs, Volume= 0.388 af
Outflow = 2.74 cfs @ 12.25 hrs, Volume= 0.388 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Reach 1R: POI#1



Summary for Pond 1P: USSF-740

Inflow Area = 1.748 ac, 56.41% Impervious, Inflow Depth = 2.81" for 10-year event
Inflow = 5.97 cfs @ 12.07 hrs, Volume= 0.410 af
Outflow = 2.56 cfs @ 12.27 hrs, Volume= 0.364 af, Atten= 57%, Lag= 11.6 min
Primary = 2.56 cfs @ 12.27 hrs, Volume= 0.364 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 107.86' @ 12.27 hrs Surf.Area= 8,456 sf Storage= 6,001 cf

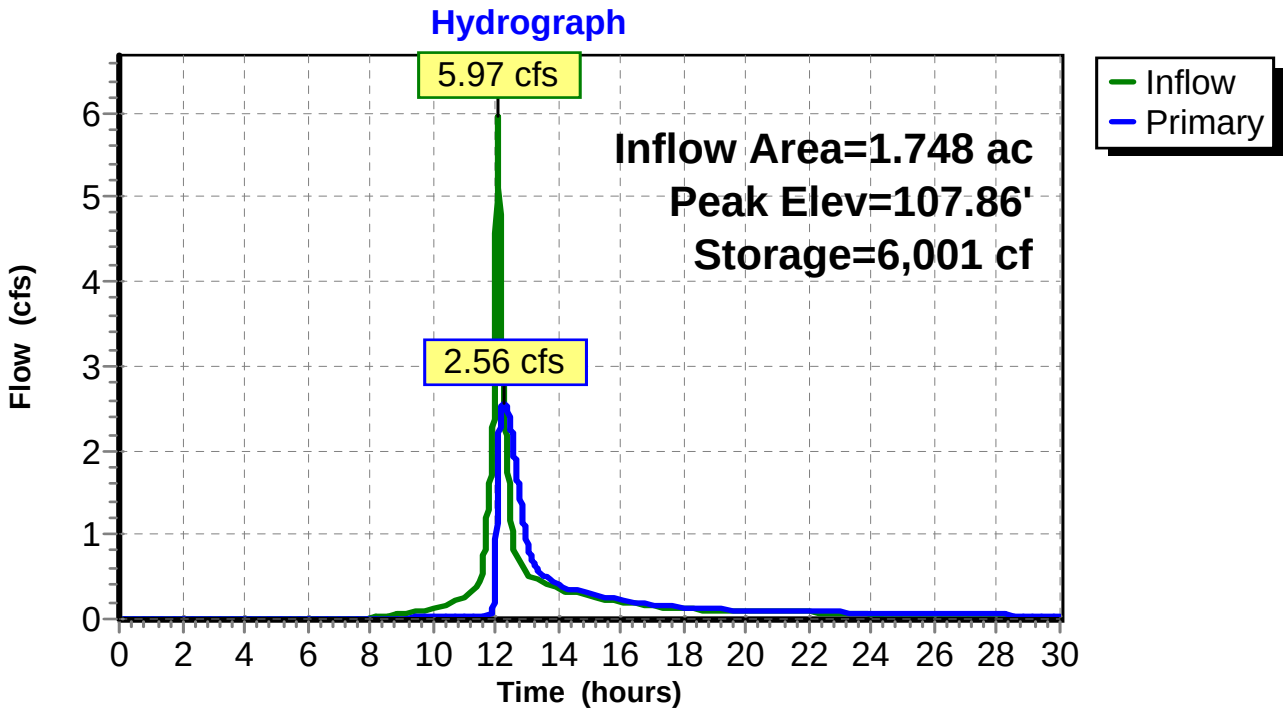
Plug-Flow detention time= 152.0 min calculated for 0.364 af (89% of inflow)
Center-of-Mass det. time= 99.1 min (917.0 - 817.9)

Volume	Invert	Avail.Storage	Storage Description
#1	105.75'	53 cf	**4.00'D x 4.25'H Vertical Cone/Cylinder**
#2	105.50'	2,580 cf	**25.75'W x 109.30'L x 3.50'H Crushed Stone** 9,851 cf Overall - 3,400 cf Embedded = 6,451 cf x 40.0% Voids
#3	105.75'	3,400 cf	**44.6"W x 30.0"H x 7.12'L StormTech SC-740** x 74 Inside #2
#4	104.00'	211 cf	**25.75'W x 109.30'L x 1.50'H Sand** 4,222 cf Overall x 5.0% Voids
#5	103.00'	1,118 cf	**25.75'W x 109.30'L x 1.00'H Crushed Stone Underdrain** 2,814 cf Overall - 19 cf Embedded = 2,795 cf x 40.0% Voids
#6	103.33'	19 cf	**4.0"D x 109.00'L Underdrains** x 2 Inside #5
		7,382 cf	Total Available Storage

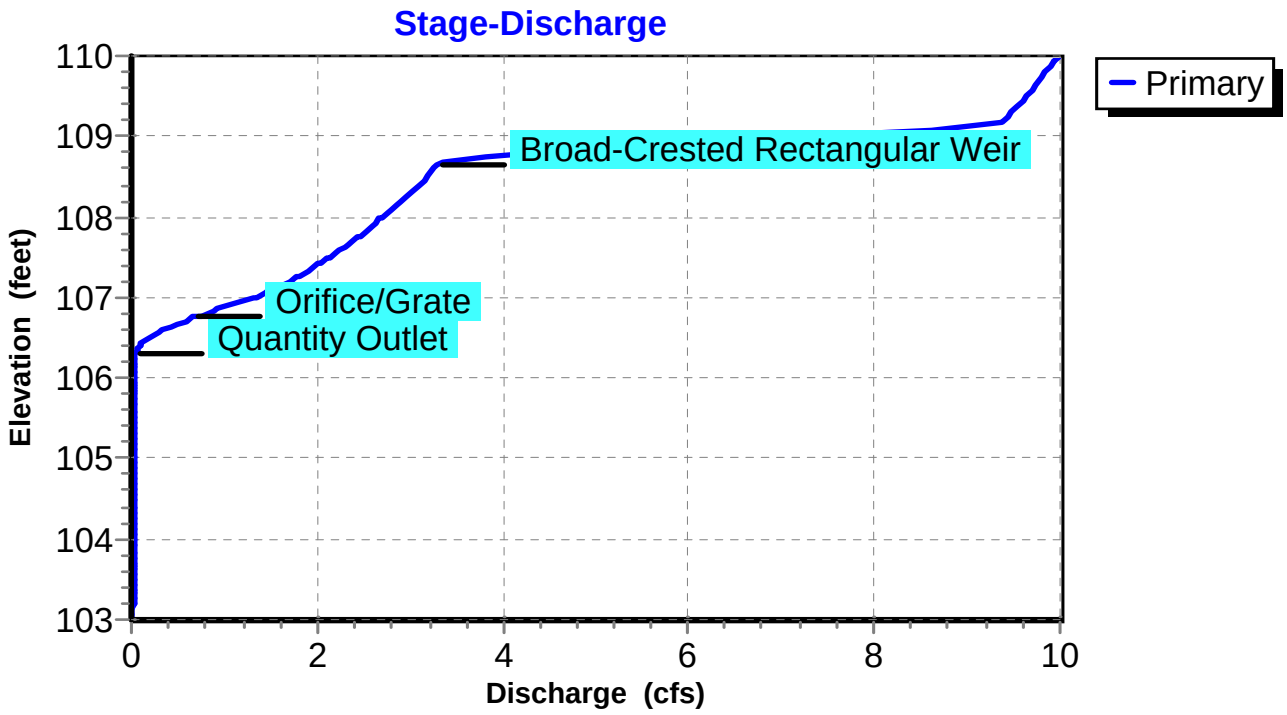
Device	Routing	Invert	Outlet Devices
#1	Primary	102.50'	**12.0" Vert. 12" Outlet to the Walnut St** C= 0.600
#2	Device 1	102.75'	**1.0" Vert. Quality Outlet** C= 0.600
#3	Device 1	106.30'	**8.8" Vert. Quantity Outlet** C= 0.600
#4	Device 1	106.75'	**3.3" Vert. Orifice/Grate** C= 0.600
#5	Device 1	108.65'	**6.0' long x 0.7' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 Coef. (English) 2.76 2.82 2.93 3.09 3.18 3.22 3.27 3.30 3.32 3.31 3.32

Primary OutFlow Max=2.56 cfs @ 12.27 hrs HW=107.86' (Free Discharge)
└**1=12" Outlet to the Walnut St** (Passes 2.56 cfs of 8.34 cfs potential flow)
- **2=Quality Outlet** (Orifice Controls 0.06 cfs @ 10.84 fps)
- **3=Quantity Outlet** (Orifice Controls 2.22 cfs @ 5.26 fps)
- **4=Orifice/Grate** (Orifice Controls 0.28 cfs @ 4.75 fps)
- **5=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

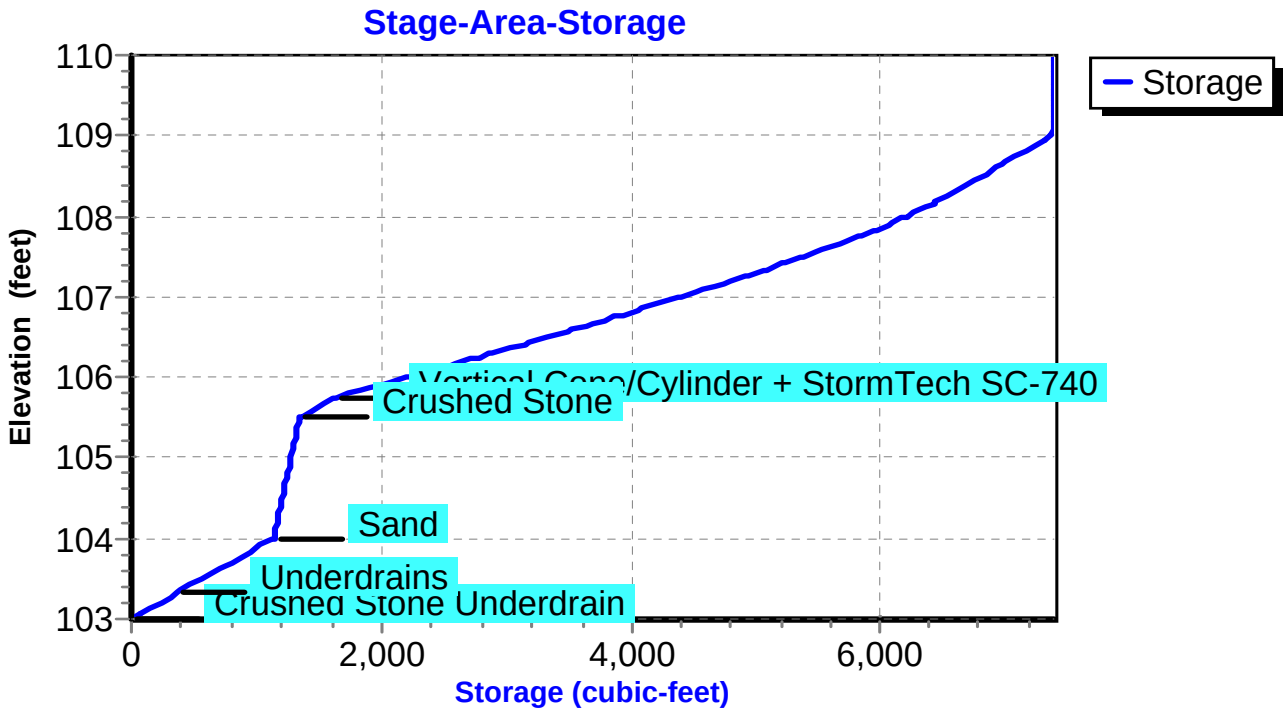
Pond 1P: USSF-740



Pond 1P: USSF-740



Pond 1P: USSF-740



Summary for Subcatchment 1S: Development

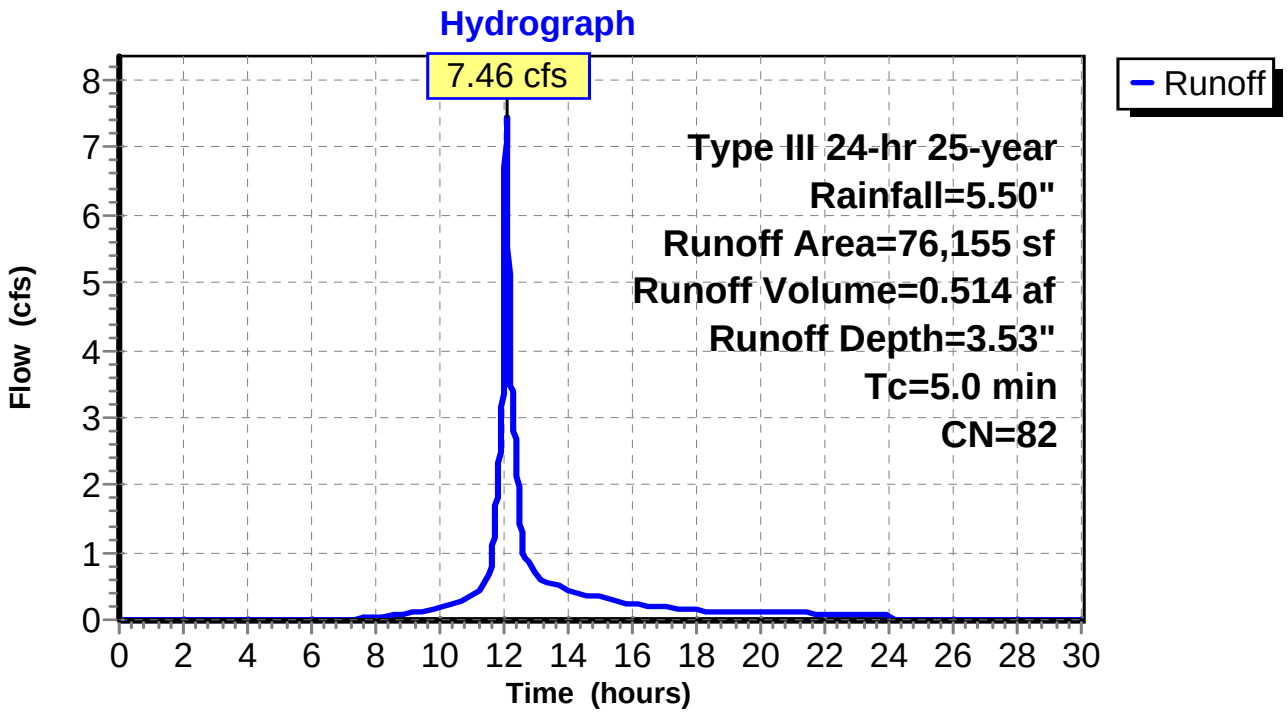
Runoff = 7.46 cfs @ 12.07 hrs, Volume= 0.514 af, Depth= 3.53"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	4,348	55	Woods, Good, HSG B
	28,848	61	>75% Grass cover, Good, HSG B
*	1,284	98	Existing Sidewalk
*	22,132	98	Proposed Buildings
*	4,043	98	Existing Buildings
*	15,500	98	Pavement
	76,155	82	Weighted Average
	33,196		Pervious Area
	42,959		Impervious Area

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

Subcatchment 1S: Development



Summary for Subcatchment 2S: No treatment

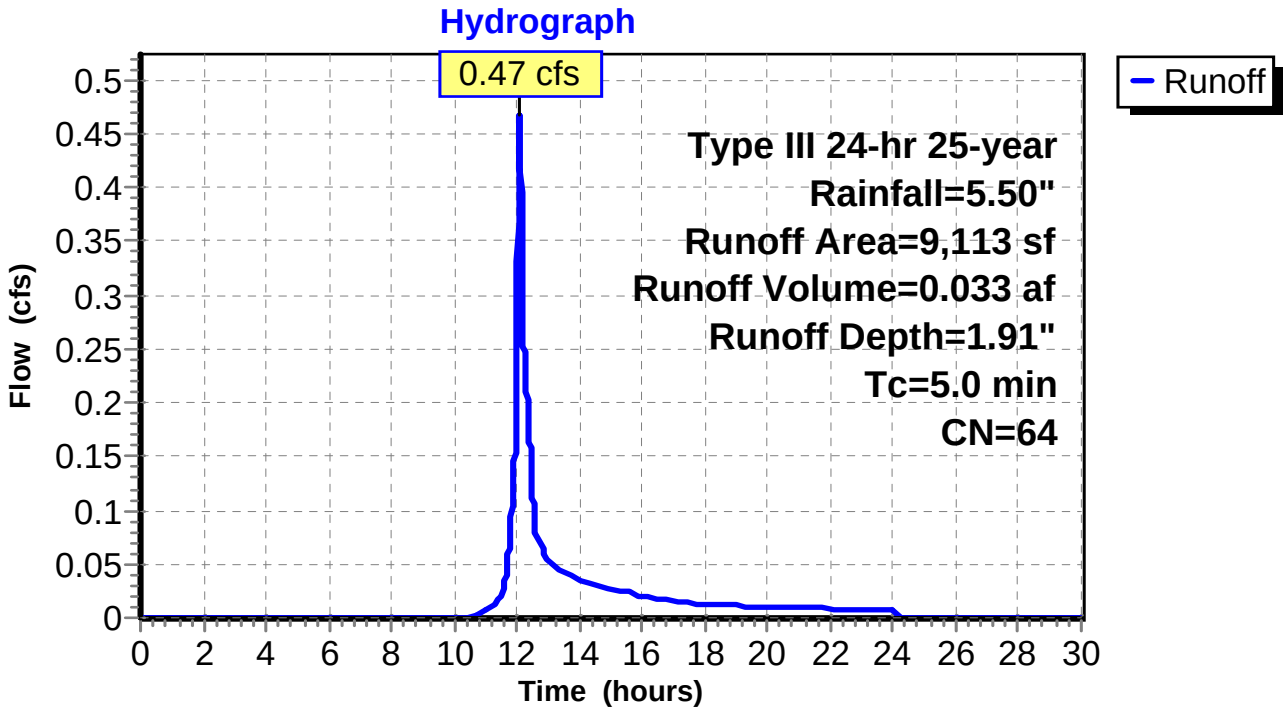
Runoff = 0.47 cfs @ 12.08 hrs, Volume= 0.033 af, Depth= 1.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	8,469	61	>75% Grass cover, Good, HSG B
*	644	98	Sidewalk to East Cove
	9,113	64	Weighted Average
	8,469		Pervious Area
	644		Impervious Area

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

Subcatchment 2S: No treatment

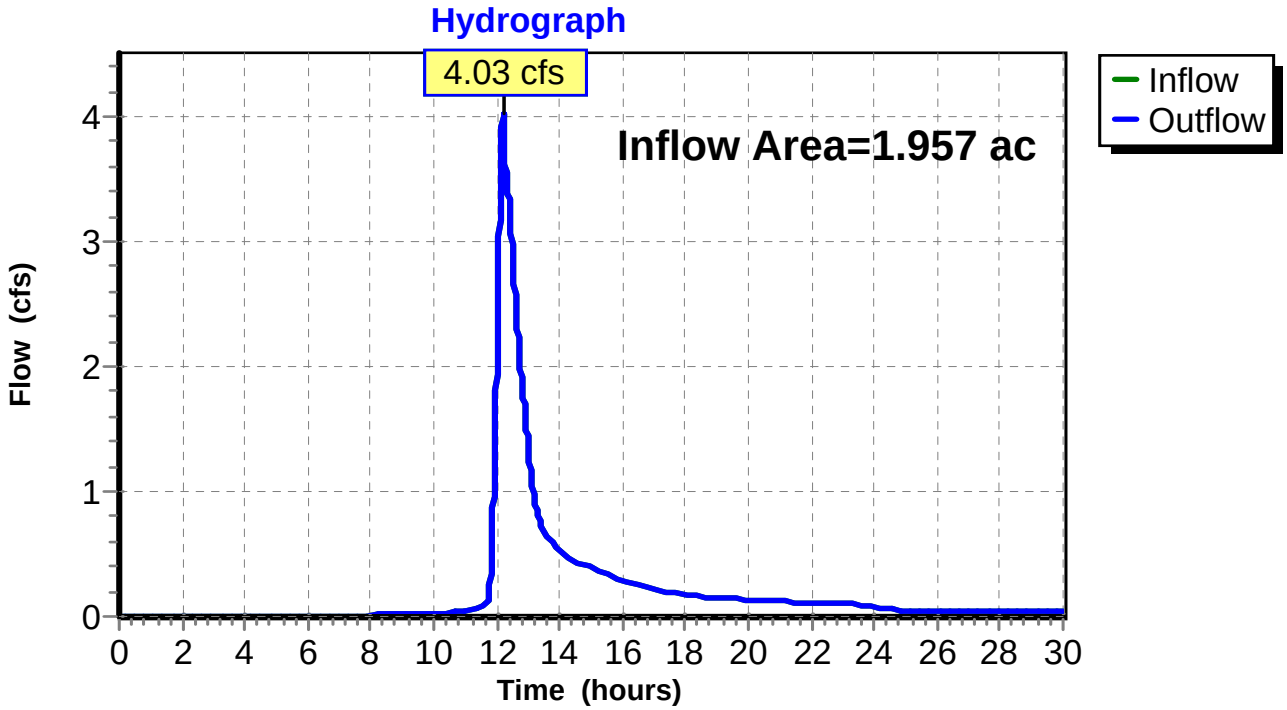


Summary for Reach 1R: POI#1

Inflow Area = 1.957 ac, 51.14% Impervious, Inflow Depth > 3.07" for 25-year event
Inflow = 4.03 cfs @ 12.20 hrs, Volume= 0.501 af
Outflow = 4.03 cfs @ 12.20 hrs, Volume= 0.501 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs

Reach 1R: POI#1



Summary for Pond 1P: USSF-740

Inflow Area = 1.748 ac, 56.41% Impervious, Inflow Depth = 3.53" for 25-year event
Inflow = 7.46 cfs @ 12.07 hrs, Volume= 0.514 af
Outflow = 3.76 cfs @ 12.21 hrs, Volume= 0.468 af, Atten= 50%, Lag= 8.0 min
Primary = 3.76 cfs @ 12.21 hrs, Volume= 0.468 af

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.01 hrs
Peak Elev= 108.73' @ 12.21 hrs Surf.Area= 8,456 sf Storage= 7,062 cf

Plug-Flow detention time= 129.1 min calculated for 0.468 af (91% of inflow)
Center-of-Mass det. time= 83.9 min (895.4 - 811.5)

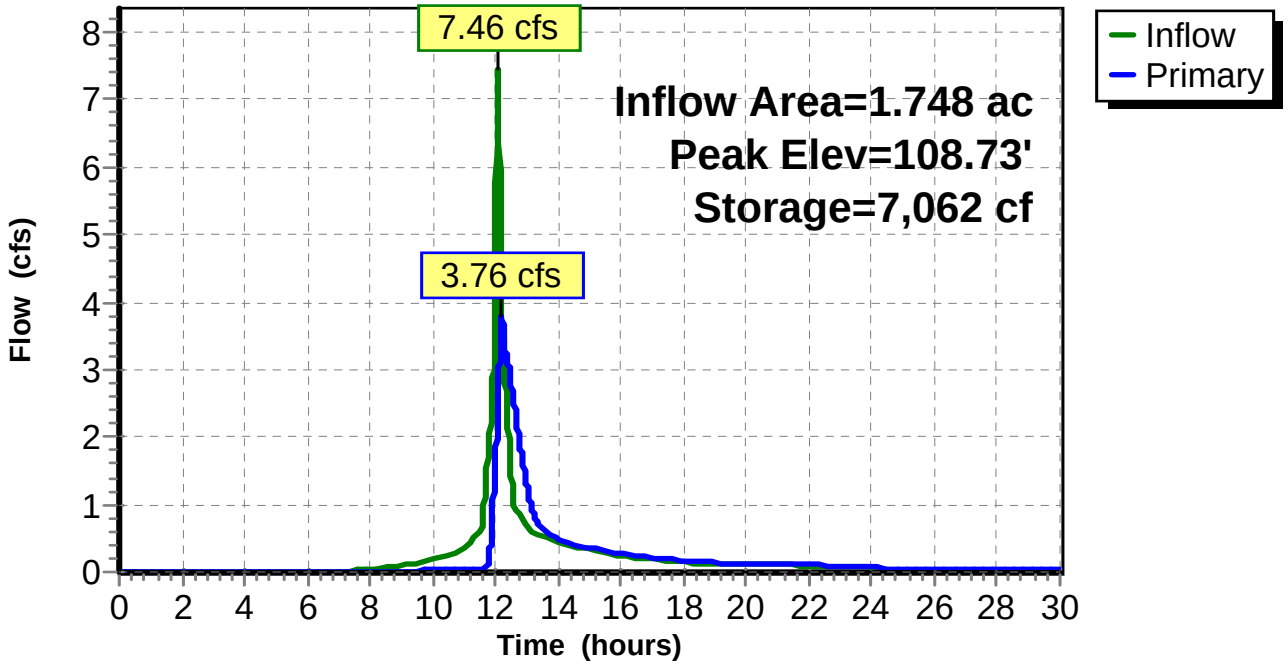
Volume	Invert	Avail.Storage	Storage Description
#1	105.75'	53 cf	**4.00'D x 4.25'H Vertical Cone/Cylinder**
#2	105.50'	2,580 cf	**25.75'W x 109.30'L x 3.50'H Crushed Stone** 9,851 cf Overall - 3,400 cf Embedded = 6,451 cf x 40.0% Voids
#3	105.75'	3,400 cf	**44.6"W x 30.0"H x 7.12'L StormTech SC-740** x 74 Inside #2
#4	104.00'	211 cf	**25.75'W x 109.30'L x 1.50'H Sand** 4,222 cf Overall x 5.0% Voids
#5	103.00'	1,118 cf	**25.75'W x 109.30'L x 1.00'H Crushed Stone Underdrain** 2,814 cf Overall - 19 cf Embedded = 2,795 cf x 40.0% Voids
#6	103.33'	19 cf	**4.0"D x 109.00'L Underdrains** x 2 Inside #5
		7,382 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	102.50'	**12.0" Vert. 12" Outlet to the Walnut St** C= 0.600
#2	Device 1	102.75'	**1.0" Vert. Quality Outlet** C= 0.600
#3	Device 1	106.30'	**8.8" Vert. Quantity Outlet** C= 0.600
#4	Device 1	106.75'	**3.3" Vert. Orifice/Grate** C= 0.600
#5	Device 1	108.65'	**6.0' long x 0.7' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 Coef. (English) 2.76 2.82 2.93 3.09 3.18 3.22 3.27 3.30 3.32 3.31 3.32

Primary OutFlow Max=3.75 cfs @ 12.21 hrs HW=108.73' (Free Discharge)
└**1=12" Outlet to the Walnut St** (Passes 3.75 cfs of 9.05 cfs potential flow)
- **2=Quality Outlet** (Orifice Controls 0.06 cfs @ 11.73 fps)
- **3=Quantity Outlet** (Orifice Controls 2.92 cfs @ 6.92 fps)
- **4=Orifice/Grate** (Orifice Controls 0.39 cfs @ 6.54 fps)
- **5=Broad-Crested Rectangular Weir** (Weir Controls 0.37 cfs @ 0.78 fps)

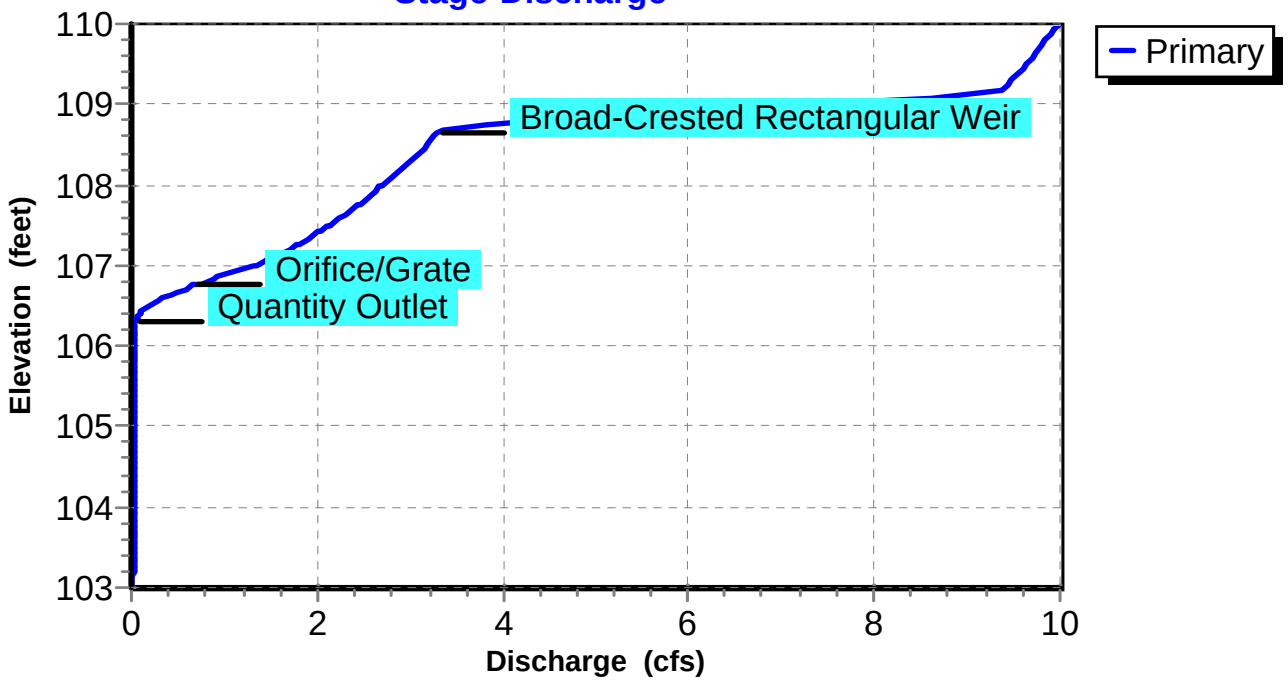
Pond 1P: USSF-740

Hydrograph

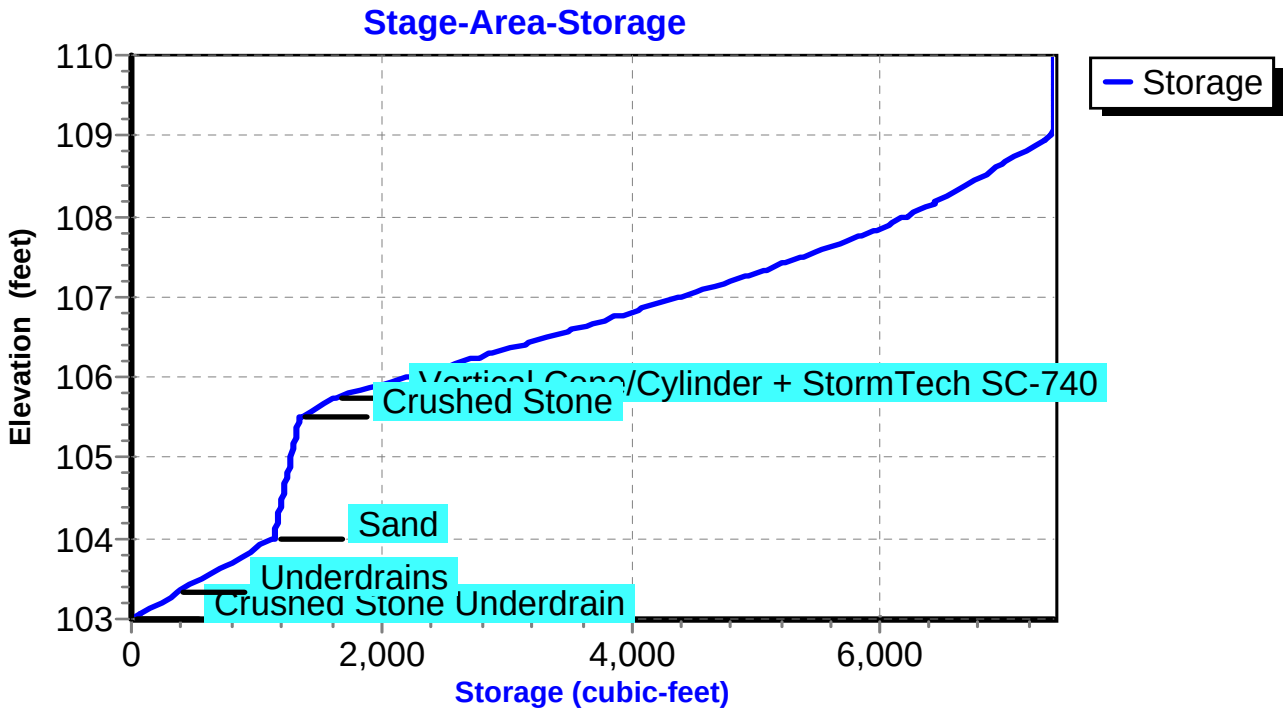


Pond 1P: USSF-740

Stage-Discharge



Pond 1P: USSF-740



Attachment E

Stormwater Operation and Maintenance Plan

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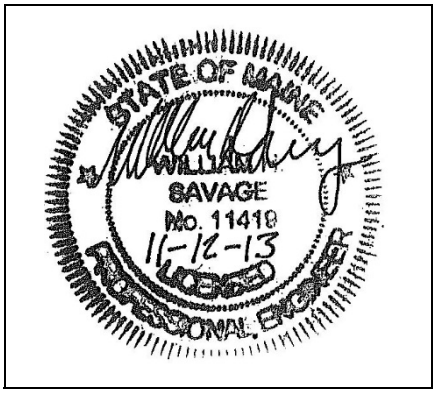
POST CONSTRUCTION - STORMWATER INSPECTION & MAINTENANCE PLAN

Prepared For:

Redfern Properties, LLC
Munjoy Heights
79 Walnut Street
Portland, Maine 04101

Prepared By:

Acorn Engineering, Inc.
PO Box 3372
Portland, Maine 04104



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ACORN ENGINEERING, INC.

RESPONSIBLE PARTY

The owner, Redfern Properties, LLC, and or their successor shall be responsible for contracting with a qualified stormwater professional to implement the Inspection and Maintenance Plan. The qualified stormwater professional shall maintain a stormwater log (report) summarizing inspections, maintenance, and corrective action taken. The Qualified Stormwater Professional shall annually submit the Stormwater Log to the Department of Public Services prior to June 30th.

The following is an example of a qualified stormwater professional that the homeowners association may contract through.

Organization: Will Savage, PE - Acorn Engineering, Inc
Phone: (207) 775-2655

Qualifications:

- Maine Professional Engineering License #11419
- Maine DEP - Certified in Maintenance & Inspection of Stormwater BMP's Cert #14
- Certified Erosion, Sediment and Storm Water Inspector (CESSWI) Cert #0293
- Certified Professional in Erosion and Sediment Control (CPESC) Cert. #4620

The inspection and maintenance criteria is based upon the Maine DEP - Stormwater Management for Maine, Volume III: BMPs Technical Design Manual. Refer to the Grading and Drainage Plan for the location of the BMPs

PURPOSE

This Inspection and Maintenance Plan has been individually tailored to this parcel's stormwater infrastructure, site characteristics, and their respective opportunities and limitations related to reducing the pollutant load on the receiving watershed. The maintenance of a parcel's impervious surfaces and stormwater infrastructure is critical to extending the long term performance and effectiveness of Best Management Practices (BMPs). The Inspection and Maintenance Plan represents the parcel's minimum activities to meet the permit requirements. The parcel shall still be subject to any applicable Civil Site Plans, Permit Applications, Erosion and Sedimentation Control Plans Reports, Stormwater Management Plans, Inspection and Maintenance Manuals, and all Municipal, State, and Federal rules.

OPERATION AND MAINTENANCE ACTIVITY

Underdrained Subsurface Sand Filter:

The maintenance of the underdrained subsurface sand filter shall be in accordance with the following activities identified below and the Stormwater Drainage System Maintenance Agreement included within Stormwater Report, Attachment F.

- The system should be inspected after every major storm in the first few months to ensure proper function. Thereafter, the filter should be inspected at least once every six months to ensure that it is draining within 24 hours to 36 hours.
- Inspect Outlet Control Structures (OCS) to ensure they are in good working order and that the orifice and trash racks are unobstructed from trash and debris.
- Inspect and maintain the StormTech Isolator Row in accordance with the attached proprietary Operation and Maintenance Plan.

Sweeping:

Annual sweeping of the parking lot following the snow melt for accumulated winter sand, if necessary. Appropriately dispose of all collected material.

Storm Drains:

The storm drain shall be annually inspected for the presence of accumulated sediment or debris. Any sediment shall be removed as required.

- The equipment shall meet the following minimum specifications; power jet and water source for washing down the storm drain, vacuum attachment for catch basin cleaning, and a liquid handling method to dewater the material.
- Inspect and legally dispose of accumulated sediment and debris within the storm drains between basins. Liquids must be decanted on-site and returned to the catch basin.

Catch Basins:

Catch basins shall be inspected to confirm the structure is operating properly.

- Inspect the presence of accumulated sediment or debris any sediment shall be removed. The equipment shall meet the following minimum specifications; power jet and water source for washing down the storm drain, vacuum attachment for catch basin cleaning, and a liquid handling method to dewater the material.
- Sediment shall be removed when accumulation is within 6 inches of the outfall pipe invert. Legally dispose of accumulated sediment and debris from the bottom of the basin, inlet grates, and inflow channels to the basin.
- If the basin outlet is designed with a hood to trap floatable materials (e.g. Snout), check to ensure watertight seal is working. Remove floating debris and hydrocarbons (e.g. using absorbent pads) at the time of the inspection.
- Remove and replace any hydrocarbon absorptive pads.
- Remove and replace any sediment sacks.
- Appropriately dispose of all collected material.

Vegetated Areas:

Inspect all vegetated slopes and embankments on an annual basis. Replant bare areas with sparse growth (<90% coverage) and armor areas showing signs of rill erosion with an appropriate lining.

INSPECTION AND MAINTENANCE TABLE

Inspection and Maintenance Frequency	Spring or Yearly	Summer	Fall	As Necessary
Underdrained Subsurface Sand Filter	X		X	X
Sweeping	X			X
Storm Drains	X			X
Catch Basins		X		X
Vegetated Areas	X			