

Hydrologic Analysis
and
Drainage Calculations

**PROPOSED SITE PLAN
“146 GEORGETOWN ROAD”
BOXFORD, MASSACHUSETTS**

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HYDROLOGIC ANALYSIS
138 Fisher Street
Westborough, MA

A. Introduction

146 Georgetown Road is a vacant land with 3.16 Acres alongside Stevens Pond as shown on Figure 1.

The owner is proposing the construction of single-family house with approximate 6,000 sq.ft. footprint as shown in Figure 2. The purpose of this analysis is to assess hydrologic impacts related to the development and to evaluate performance of the proposed stormwater management system. The analysis will demonstrate that the new construction is technically feasible, and that the development will not cause adverse impacts to the site or its environs.

B. Existing Conditions

The existing conditions plan show a contiguous parcel of land with 3.16 Acres. Historic plans shown a single-family dwelling on site, prior to the current ownership. Most of the area is disturbed, on the north side is Steven Pond the south side is bordered by Georgetown Road.

The Interim Soil Survey Report for the Essex County Conservation District reports one predominant soil types for the locus. The soils map is shown in Figure 3. The area is Hinckley loamy sand

The Natural Conservation Resource Service (formerly SCS) has mapped this area. Their mapping is included in this report and tabulated on table one.

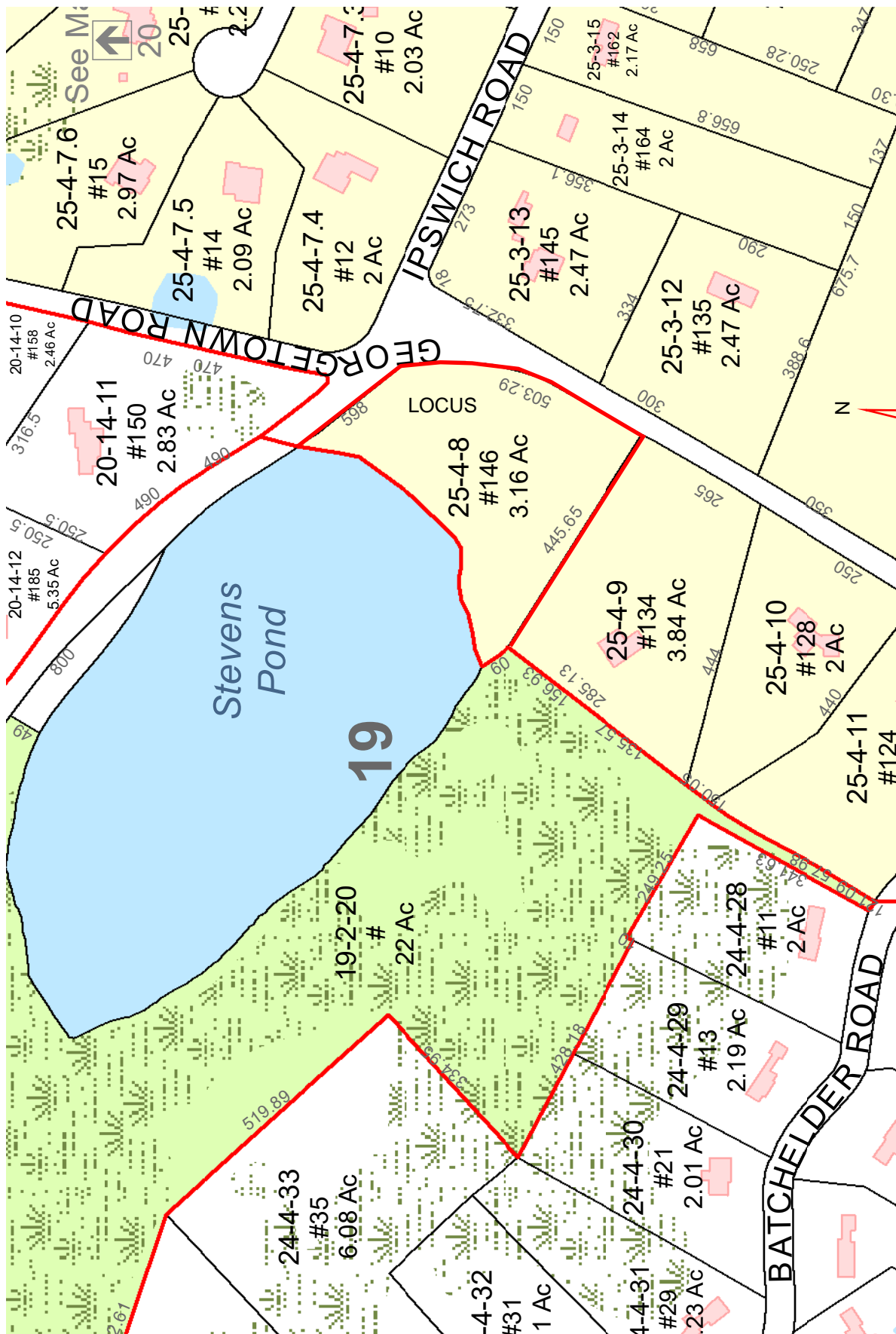
Table One: Existing Soil Types and Watershed Conditions at the locus

Symbol	Soil Series	Slope %	Hydrologic Group
253A	Hinckley loamy sand	0-3	A
253 B	Hinckley loamy sand	3-8	A

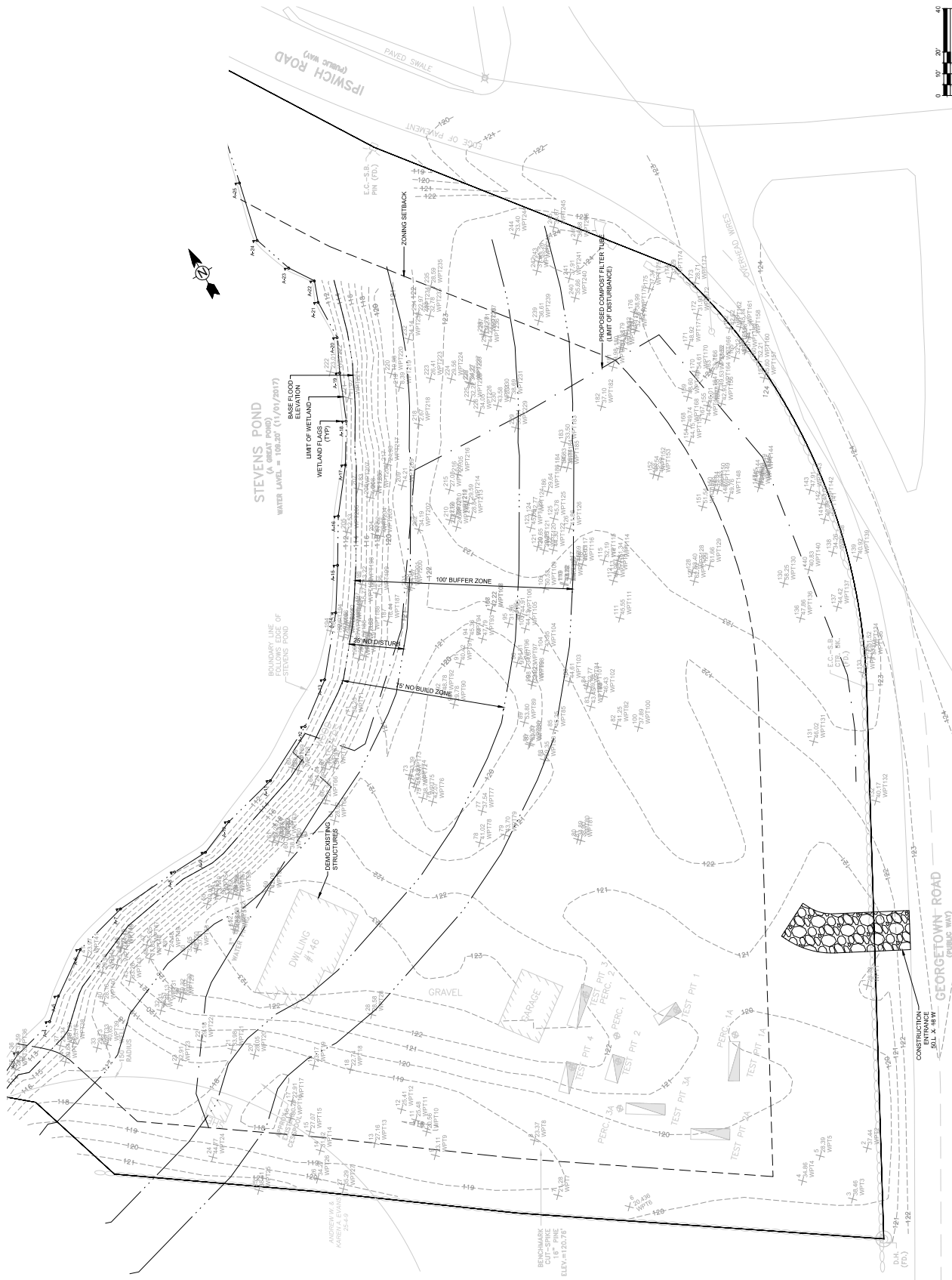
C. Stormwater Management Approach

The general approach to manage stormwater from the proposed development is to restrict post-development runoff rates for all storm events to at or below pre-development rates. Special care was taken to ensure that no new point source discharges were created.

These goals were accomplished primarily through the construction of a leaching basin to recharge runoff from the roof and driveway.



LOCUS MAP



EXISTING CONDITIONS PLAN

Soil Map—Essex County, Massachusetts, Northern Part
(146 Georgetown Road - Boxford)




Soil Map may not be valid at this scale.

Map Scale: 1:2,870 if printed on A landscape (11" x 8.5") sheet.
0 40 80 160 240 Meters
0 100 200 400 600 Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)

 Area of Interest (AOI)

Soils

 Soil 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 1:15,800.

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

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

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

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

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

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

Soil Survey Area: Essex County, Massachusetts, Northern Part
Survey Area Data: Version 16, Jun 9, 2020

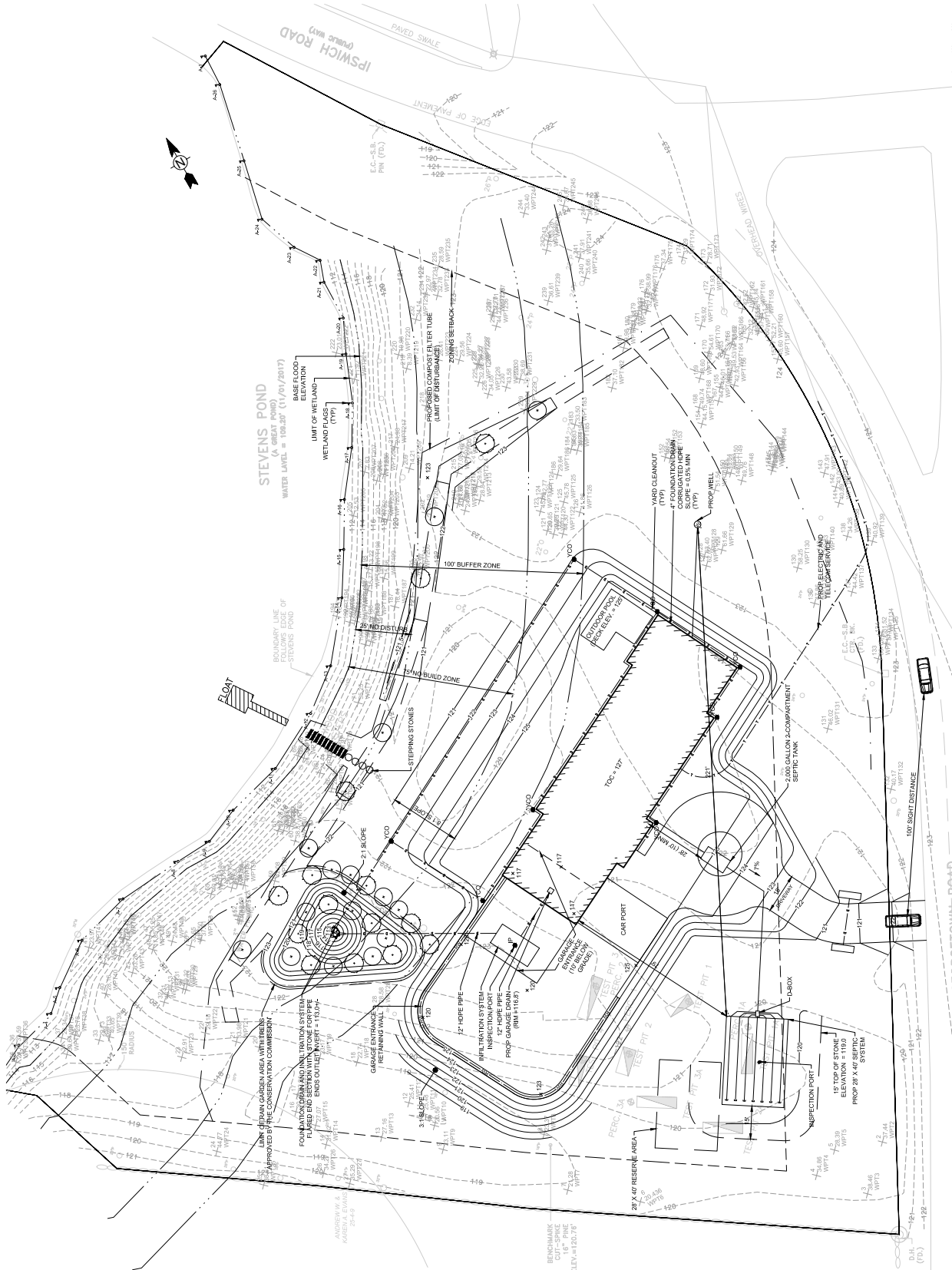
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 13, 2020—Oct 18, 2020

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
1	Water	5.8	13.6%
52A	Freetown muck, 0 to 1 percent slopes	6.0	13.9%
253A	Hinckley loamy sand, 0 to 3 percent slopes	21.0	48.9%
253B	Hinckley loamy sand, 3 to 8 percent slopes	8.5	19.8%
421B	Canton fine sandy loam, 0 to 8 percent slopes, very stony	1.7	3.9%
Totals for Area of Interest		42.9	100.0%



PROPOSED CONDITIONS PLAN

D. Analytical Approach

The sub-basin area in question is too small to create a SCS TR-55 hydrologic model. The approach used on this report is the comparison of the amount of runoff generated by the pre-development condition compared to the post-development condition using 5 minutes for time of concentration (assumed). Based on that we reduce the amount of runoff infiltrated by the proposed infiltration system.

Design storms, using an SCS Type-3 24-hour rainfall distribution, were considered for storms with return periods of two, ten and 100-years.

E. Pre-Development Analysis

The complete watershed delineation is shown on the attached “Pre-Development Watershed Delineation Basin Plan” is shown on figure 4.

Table Two: Existing Watershed Conditions for Drainage Basin

Pre Development

Land Use	Subcatchment Areas (acres)	
	E-1A	Total
Pavement	0.15	0.15
Roof	0.05	0.05
Grass - HSG A	1.14	1.14
Woods - HSG A	1.30	1.30
Total	2.64	2.64

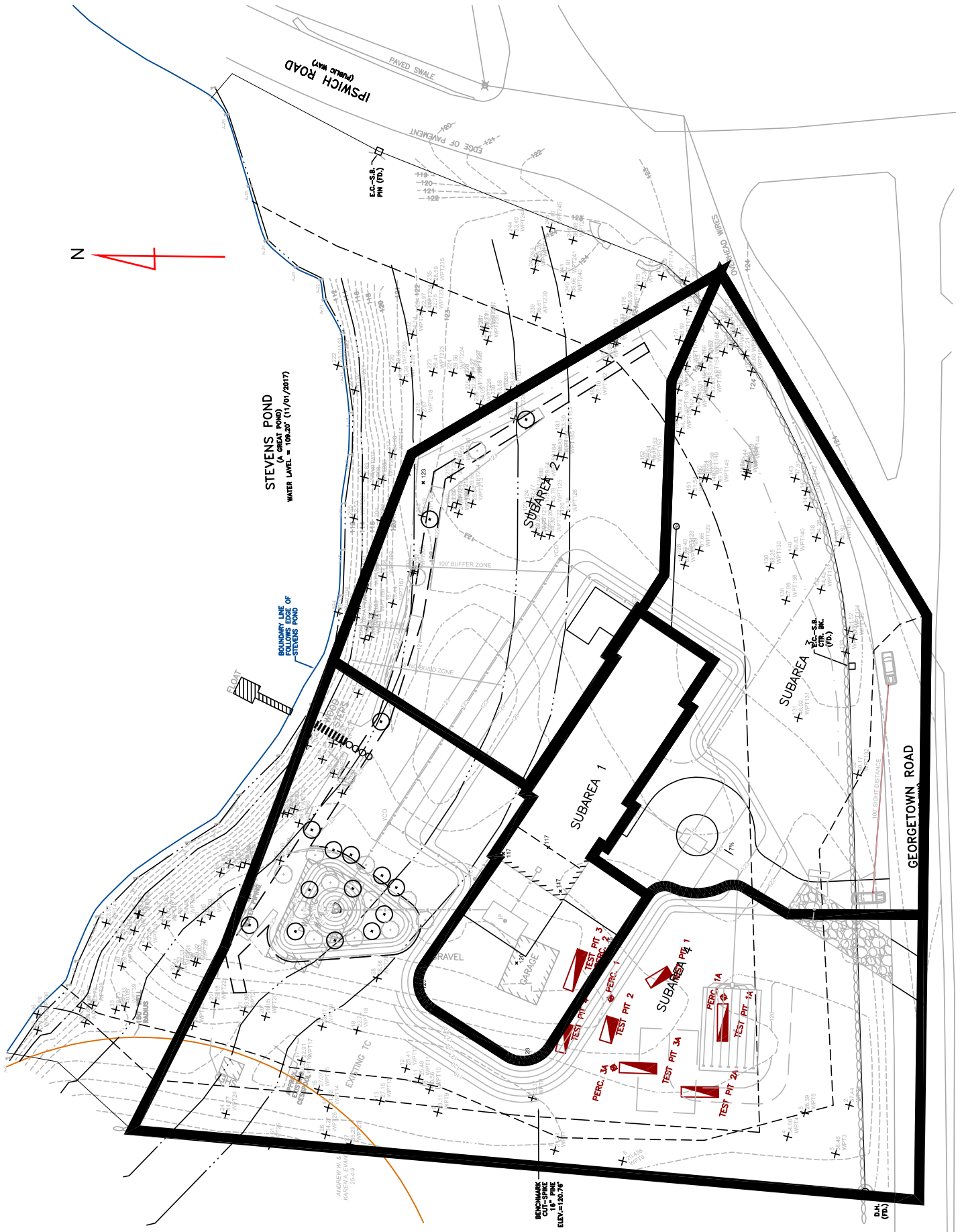
F. Post-Development Analysis

The complete watershed delineation is shown on the attached “Post-Development Watershed Delineation Basin Plan” is shown on figure 5.

Table Three: Proposed Watershed Conditions for Drainage Basin

Post Development

Land Use	Subcatchment Areas (acres)				
	P-1	P-2	P-3	P-4	Total
Pavement	0.14	0.00	0.10	0.00	0.24
Roof	0.14	0.01	0.00	0.00	0.15
Grass - HSG A	0.00	0.34	0.62	0.30	1.26
Woods - HSG A	0.00	0.17	0.00	0.82	0.99
Total	0.28	0.52	0.72	1.12	2.64



POST DEVELOPMENT SUB-CATCHMENT

G. Model Results

The project net increase in impervious area is 0.19 Acres

Existing Impervious Area =	0.20
Proposed Impervious Area =	0.39
Net Increase =	0.19

Imp. Area to Inf. BMP =	0.28
-------------------------	------

The results of the hydrologic model indicate that the proposed storm water management system will be effective in controlling runoff rates. Table Four presents a comparison of pre- and post-development runoff rates from the site and Table Five presents a comparison of pre- and post-development runoff volume from the site.

Table Four: Comparison of Pre- and Post-Development Runoff Rates
Comparison of Peak Runoff Rates

Design Point 1R

Storm Event (years)	Peak Runoff (cfs)		
	Pre Development	Post Development	Δ
2	0.00	0.00	0.00
10	0.14	0.12	-0.02
100	2.38	1.56	-0.82

Table Five: Comparison of Pre- and Post-Development Volume Rates

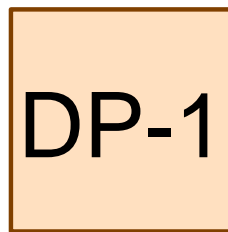
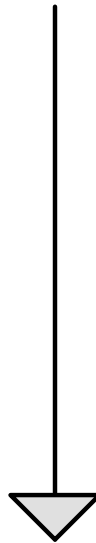
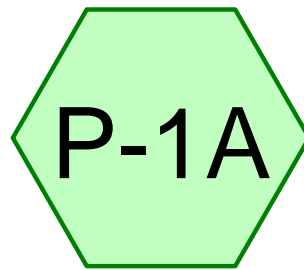
Design Point 1R

Storm Event (years)	Peak Runoff Volume (af)		
	Pre Development	Post Development	Δ
2	0.000	0.000	0.000
10	0.050	0.032	-0.018
100	0.267	0.208	-0.059

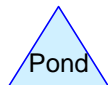
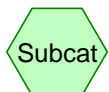
The results indicate, the storm water system adopted will effectively control discharge rates from the site and maintain discharge levels below pre-development levels. Also, by promoting infiltration on site we maintain the runoff volume below pre-development rate. For the 100-year storm the system is reducing overall runoff from the property by 82%. Complete hydrologic computations are included in the appendix section of this report.

APPENDIX A

PRE-DEVELOPMENT HYDROLOGIC CALCULATIONS



DESIGN POINT 1
(STEVENS POND)



Pre-Development_boxford

Type III 24-hr 2-Year Rainfall=3.25"

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Summary for Subcatchment P-1A:

Runoff = 0.00 cfs @ 24.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.25"

Area (ac)	CN	Description
0.150	98	Paved parking, HSG B
0.050	98	Roofs, HSG B
1.140	39	>75% Grass cover, Good, HSG A
1.300	30	Woods, Good, HSG A
2.640	39	Weighted Average
2.440		92.42% Pervious Area
0.200		7.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	32	0.0480	1.61		Sheet Flow, Smooth surfaces n= 0.011 P2= 3.43"
6.0	578	0.0100	1.61		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	37	0.1400	5.61		Shallow Concentrated Flow, Shallow Concentrated Grassed Waterway Kv= 15.0 fps
6.4	647	Total			

Summary for Reach DP-1: DESIGN POINT 1 (STEVENS POND)

Inflow Area = 2.640 ac, 7.58% Impervious, Inflow Depth = 0.00" for 2-Year event

Inflow = 0.00 cfs @ 24.00 hrs, Volume= 0.000 af

Outflow = 0.00 cfs @ 24.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Pre-Development_boxford

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Type III 24-hr 10-Year Rainfall=5.14"

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Summary for Subcatchment P-1A:

Runoff = 0.14 cfs @ 12.46 hrs, Volume= 0.050 af, Depth= 0.23"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=5.14"

Area (ac)	CN	Description
0.150	98	Paved parking, HSG B
0.050	98	Roofs, HSG B
1.140	39	>75% Grass cover, Good, HSG A
1.300	30	Woods, Good, HSG A
2.640	39	Weighted Average
2.440		92.42% Pervious Area
0.200		7.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	32	0.0480	1.61		Sheet Flow, Smooth surfaces n= 0.011 P2= 3.43"
6.0	578	0.0100	1.61		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	37	0.1400	5.61		Shallow Concentrated Flow, Shallow Concentrated Grassed Waterway Kv= 15.0 fps
6.4	647	Total			

Summary for Reach DP-1: DESIGN POINT 1 (STEVENS POND)

Inflow Area = 2.640 ac, 7.58% Impervious, Inflow Depth = 0.23" for 10-Year event

Inflow = 0.14 cfs @ 12.46 hrs, Volume= 0.050 af

Outflow = 0.14 cfs @ 12.46 hrs, Volume= 0.050 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Pre-Development_boxford

Type III 24-hr 100-Year Rainfall=8.13"

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Summary for Subcatchment P-1A:

Runoff = 2.38 cfs @ 12.13 hrs, Volume= 0.267 af, Depth= 1.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.13"

Area (ac)	CN	Description
0.150	98	Paved parking, HSG B
0.050	98	Roofs, HSG B
1.140	39	>75% Grass cover, Good, HSG A
1.300	30	Woods, Good, HSG A
2.640	39	Weighted Average
2.440		92.42% Pervious Area
0.200		7.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	32	0.0480	1.61		Sheet Flow, Smooth surfaces n= 0.011 P2= 3.43"
6.0	578	0.0100	1.61		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.1	37	0.1400	5.61		Shallow Concentrated Flow, Shallow Concentrated Grassed Waterway Kv= 15.0 fps
6.4	647	Total			

Summary for Reach DP-1: DESIGN POINT 1 (STEVENS POND)

Inflow Area = 2.640 ac, 7.58% Impervious, Inflow Depth = 1.21" for 100-Year event

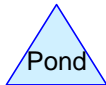
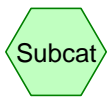
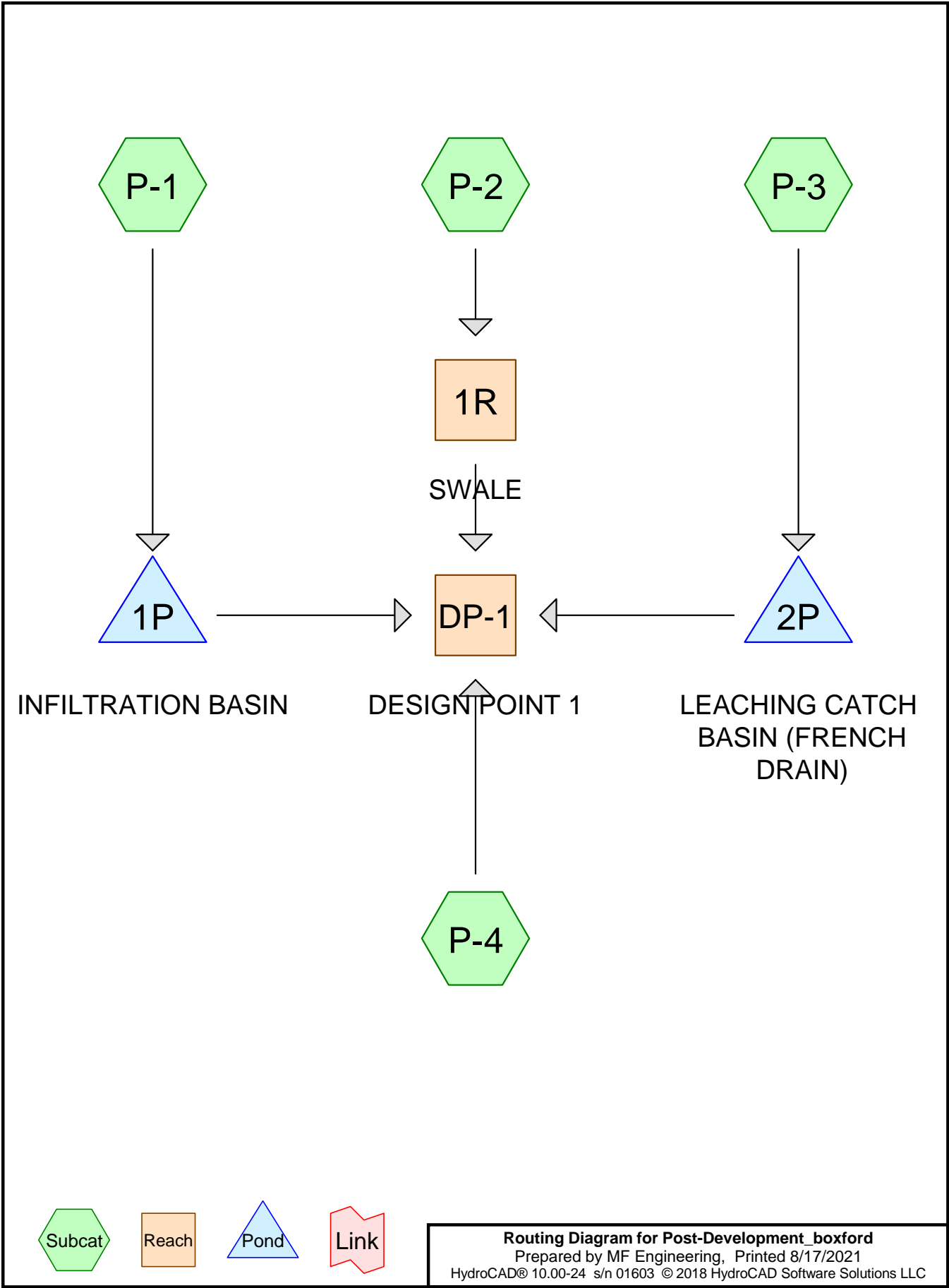
Inflow = 2.38 cfs @ 12.13 hrs, Volume= 0.267 af

Outflow = 2.38 cfs @ 12.13 hrs, Volume= 0.267 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

APPENDIX B

POST-DEVELOPMENT HYDROLOGIC CALCULATIONS



Routing Diagram for Post-Development_boxford
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Post-Development_boxford

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Type III 24-hr 2-Year Rainfall=3.25"

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Summary for Subcatchment P-1:

Runoff = 0.89 cfs @ 12.07 hrs, Volume= 0.070 af, Depth= 3.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.25"

Area (ac)	CN	Description
0.140	98	Paved parking, HSG A
0.140	98	Roofs, HSG A
0.280	98	Weighted Average
0.280		100.00% Impervious Area

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

Summary for Subcatchment P-2:

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.25"

Area (ac)	CN	Description
0.340	39	>75% Grass cover, Good, HSG A
0.010	98	Roofs, HSG A
0.170	30	Woods, Good, HSG A
0.520	37	Weighted Average
0.510		98.08% Pervious Area
0.010		1.92% Impervious Area

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

Summary for Subcatchment P-3:

Runoff = 0.01 cfs @ 14.67 hrs, Volume= 0.005 af, Depth= 0.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.25"

Area (ac)	CN	Description
0.100	98	Paved parking, HSG A
0.620	39	>75% Grass cover, Good, HSG A
0.720	47	Weighted Average
0.620		86.11% Pervious Area
0.100		13.89% Impervious Area

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Type III 24-hr 2-Year Rainfall=3.25"

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

Summary for Subcatchment P-4:

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.25"

Area (ac)	CN	Description
0.300	39	>75% Grass cover, Good, HSG A
0.820	30	Woods, Good, HSG A
1.120	32	Weighted Average
1.120		100.00% Pervious Area

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

Summary for Reach 1R: SWALE

Inflow Area = 0.520 ac, 1.92% Impervious, Inflow Depth = 0.00" for 2-Year event
 Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
 Max. Velocity= 0.00 fps, Min. Travel Time= 0.0 min
 Avg. Velocity = 0.00 fps, Avg. Travel Time= 0.0 min

Peak Storage= 0 cf @ 0.00 hrs
 Average Depth at Peak Storage= 0.00'
 Bank-Full Depth= 1.00' Flow Area= 9.0 sf, Capacity= 5.81 cfs

6.00' x 1.00' deep channel, n= 0.150 Sheet flow over Short Grass
 Side Slope Z-value= 3.0 ' / ' Top Width= 12.00'
 Length= 310.0' Slope= 0.0065 ' / '
 Inlet Invert= 124.00', Outlet Invert= 122.00'



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Type III 24-hr 2-Year Rainfall=3.25"

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Summary for Reach DP-1: DESIGN POINT 1

Inflow Area = 2.640 ac, 14.77% Impervious, Inflow Depth = 0.00" for 2-Year event
 Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
 Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond 1P: INFILTRATION BASIN

Used more restrictive B layer

Inflow Area = 0.280 ac, 100.00% Impervious, Inflow Depth = 3.02" for 2-Year event
 Inflow = 0.89 cfs @ 12.07 hrs, Volume= 0.070 af
 Outflow = 0.05 cfs @ 13.83 hrs, Volume= 0.070 af, Atten= 94%, Lag= 105.7 min
 Discarded = 0.05 cfs @ 13.83 hrs, Volume= 0.070 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
 Peak Elev= 119.29' @ 13.83 hrs Surf.Area= 898 sf Storage= 1,846 cf

Plug-Flow detention time= 552.9 min calculated for 0.070 af (100% of inflow)
 Center-of-Mass det. time= 553.6 min (1,308.7 - 755.1)

Volume	Invert	Avail.Storage	Storage Description
#1	113.00'	8,519 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
113.00	17	0	0
114.00	59	38	38
115.00	126	93	131
116.00	219	173	303
117.00	336	278	581
118.00	517	427	1,007
119.00	694	606	1,613
120.00	1,387	1,041	2,653
121.00	1,705	1,546	4,199
122.00	2,047	1,876	6,075
123.00	2,840	2,444	8,519

Device	Routing	Invert	Outlet Devices
#1	Primary	122.00'	30.0' long x 3.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 Coef. (English) 2.44 2.58 2.68 2.67 2.65 2.64 2.64 2.68 2.68 2.72 2.81 2.92 2.97 3.07 3.32
#2	Discarded	113.00'	2.410 in/hr Exfiltration over Surface area

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Type III 24-hr 2-Year Rainfall=3.25"

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Discarded OutFlow Max=0.05 cfs @ 13.83 hrs HW=119.29' (Free Discharge)

↑**2=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=113.00' (Free Discharge)

↑**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 2P: LEACHING CATCH BASIN (FRENCH DRAIN)

Inflow Area = 0.720 ac, 13.89% Impervious, Inflow Depth = 0.08" for 2-Year event
Inflow = 0.01 cfs @ 14.67 hrs, Volume= 0.005 af
Outflow = 0.01 cfs @ 15.82 hrs, Volume= 0.005 af, Atten= 13%, Lag= 68.9 min
Discarded = 0.01 cfs @ 15.82 hrs, Volume= 0.005 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 119.08' @ 15.82 hrs Surf.Area= 0.003 ac Storage= 0.000 af

Plug-Flow detention time= 13.3 min calculated for 0.005 af (100% of inflow)
Center-of-Mass det. time= 13.2 min (1,065.2 - 1,052.0)

Volume	Invert	Avail.Storage	Storage Description
#1	119.00'	0.008 af	36.0" W x 36.0" H Box Pipe Storage/Trenches x 2 L= 20.0'
#2	119.00'	0.001 af	18.0" Round Pipe Storage L= 18.0' S= 0.0500 '/'
		0.009 af	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	120.50'	72.0" x 120.0" Horiz. Orifice/Grate X 2.00 C= 0.600 Limited to weir flow at low heads
#2	Discarded	119.00'	2.410 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.01 cfs @ 15.82 hrs HW=119.08' (Free Discharge)

↑**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=119.00' (Free Discharge)

↑**1=Orifice/Grate** (Controls 0.00 cfs)

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Type III 24-hr 10-Year Rainfall=5.14"

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Summary for Subcatchment P-1:

Runoff = 1.42 cfs @ 12.07 hrs, Volume= 0.114 af, Depth= 4.90"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=5.14"

Area (ac)	CN	Description
0.140	98	Paved parking, HSG A
0.140	98	Roofs, HSG A
0.280	98	Weighted Average
0.280		100.00% Impervious Area

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

Summary for Subcatchment P-2:

Runoff = 0.01 cfs @ 13.73 hrs, Volume= 0.007 af, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=5.14"

Area (ac)	CN	Description
0.340	39	>75% Grass cover, Good, HSG A
0.010	98	Roofs, HSG A
0.170	30	Woods, Good, HSG A
0.520	37	Weighted Average
0.510		98.08% Pervious Area
0.010		1.92% Impervious Area

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

Summary for Subcatchment P-3:

Runoff = 0.25 cfs @ 12.13 hrs, Volume= 0.035 af, Depth= 0.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=5.14"

Area (ac)	CN	Description
0.100	98	Paved parking, HSG A
0.620	39	>75% Grass cover, Good, HSG A
0.720	47	Weighted Average
0.620		86.11% Pervious Area
0.100		13.89% Impervious Area

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Type III 24-hr 10-Year Rainfall=5.14"

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

Summary for Subcatchment P-4:

Runoff = 0.00 cfs @ 17.13 hrs, Volume= 0.003 af, Depth= 0.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=5.14"

Area (ac)	CN	Description
0.300	39	>75% Grass cover, Good, HSG A
0.820	30	Woods, Good, HSG A
1.120	32	Weighted Average
1.120		100.00% Pervious Area

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

Summary for Reach 1R: SWALE

Inflow Area = 0.520 ac, 1.92% Impervious, Inflow Depth = 0.16" for 10-Year event

Inflow = 0.01 cfs @ 13.73 hrs, Volume= 0.007 af

Outflow = 0.01 cfs @ 16.62 hrs, Volume= 0.007 af, Atten= 10%, Lag= 173.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.07 fps, Min. Travel Time= 75.5 min

Avg. Velocity = 0.05 fps, Avg. Travel Time= 113.5 min

Peak Storage= 47 cf @ 15.37 hrs

Average Depth at Peak Storage= 0.02'

Bank-Full Depth= 1.00' Flow Area= 9.0 sf, Capacity= 5.81 cfs

6.00' x 1.00' deep channel, n= 0.150 Sheet flow over Short Grass

Side Slope Z-value= 3.0 ' Top Width= 12.00'

Length= 310.0' Slope= 0.0065 ' /'

Inlet Invert= 124.00', Outlet Invert= 122.00'



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Type III 24-hr 10-Year Rainfall=5.14"

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Summary for Reach DP-1: DESIGN POINT 1

Inflow Area = 2.640 ac, 14.77% Impervious, Inflow Depth = 0.14" for 10-Year event
 Inflow = 0.12 cfs @ 12.40 hrs, Volume= 0.032 af
 Outflow = 0.12 cfs @ 12.40 hrs, Volume= 0.032 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond 1P: INFILTRATION BASIN

Used more restrictive B layer

Inflow Area = 0.280 ac, 100.00% Impervious, Inflow Depth = 4.90" for 10-Year event
 Inflow = 1.42 cfs @ 12.07 hrs, Volume= 0.114 af
 Outflow = 0.08 cfs @ 13.77 hrs, Volume= 0.114 af, Atten= 94%, Lag= 101.7 min
 Discarded = 0.08 cfs @ 13.77 hrs, Volume= 0.114 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
 Peak Elev= 120.25' @ 13.77 hrs Surf.Area= 1,466 sf Storage= 3,008 cf

Plug-Flow detention time= 558.8 min calculated for 0.114 af (100% of inflow)
 Center-of-Mass det. time= 559.6 min (1,306.2 - 746.6)

Volume	Invert	Avail.Storage	Storage Description
#1	113.00'	8,519 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
113.00	17	0	0
114.00	59	38	38
115.00	126	93	131
116.00	219	173	303
117.00	336	278	581
118.00	517	427	1,007
119.00	694	606	1,613
120.00	1,387	1,041	2,653
121.00	1,705	1,546	4,199
122.00	2,047	1,876	6,075
123.00	2,840	2,444	8,519

Device	Routing	Invert	Outlet Devices
#1	Primary	122.00'	30.0' long x 3.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 Coef. (English) 2.44 2.58 2.68 2.67 2.65 2.64 2.64 2.68 2.68 2.72 2.81 2.92 2.97 3.07 3.32
#2	Discarded	113.00'	2.410 in/hr Exfiltration over Surface area

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Type III 24-hr 10-Year Rainfall=5.14"

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Discarded OutFlow Max=0.08 cfs @ 13.77 hrs HW=120.25' (Free Discharge)

↑**2=Exfiltration** (Exfiltration Controls 0.08 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=113.00' (Free Discharge)

↑**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 2P: LEACHING CATCH BASIN (FRENCH DRAIN)

Inflow Area = 0.720 ac, 13.89% Impervious, Inflow Depth = 0.59" for 10-Year event
 Inflow = 0.25 cfs @ 12.13 hrs, Volume= 0.035 af
 Outflow = 0.13 cfs @ 12.40 hrs, Volume= 0.034 af, Atten= 48%, Lag= 16.0 min
 Discarded = 0.01 cfs @ 25.60 hrs, Volume= 0.013 af
 Primary = 0.12 cfs @ 12.40 hrs, Volume= 0.022 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 120.50' @ 12.40 hrs Surf.Area= 0.003 ac Storage= 0.005 af

Plug-Flow detention time= 149.6 min calculated for 0.034 af (97% of inflow)
Center-of-Mass det. time= 133.6 min (1,060.6 - 927.0)

Volume	Invert	Avail.Storage	Storage Description
#1	119.00'	0.008 af	36.0" W x 36.0" H Box Pipe Storage/Trenches x 2 L= 20.0'
#2	119.00'	0.001 af	18.0" Round Pipe Storage L= 18.0' S= 0.0500 '/'
		0.009 af	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	120.50'	72.0" x 120.0" Horiz. Orifice/Grate X 2.00 C= 0.600 Limited to weir flow at low heads
#2	Discarded	119.00'	2.410 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.01 cfs @ 25.60 hrs HW=120.20' (Free Discharge)

↑**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.04 cfs @ 12.40 hrs HW=120.50' (Free Discharge)

↑**1=Orifice/Grate** (Weir Controls 0.04 cfs @ 0.19 fps)

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Type III 24-hr 100-Year Rainfall=8.13"

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Summary for Subcatchment P-1:

Runoff = 2.25 cfs @ 12.07 hrs, Volume= 0.184 af, Depth= 7.89"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.13"

Area (ac)	CN	Description
0.140	98	Paved parking, HSG A
0.140	98	Roofs, HSG A
0.280	98	Weighted Average
0.280		100.00% Impervious Area

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

Summary for Subcatchment P-2:

Runoff = 0.37 cfs @ 12.12 hrs, Volume= 0.044 af, Depth= 1.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.13"

Area (ac)	CN	Description
0.340	39	>75% Grass cover, Good, HSG A
0.010	98	Roofs, HSG A
0.170	30	Woods, Good, HSG A
0.520	37	Weighted Average
0.510		98.08% Pervious Area
0.010		1.92% Impervious Area

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

Summary for Subcatchment P-3:

Runoff = 1.52 cfs @ 12.09 hrs, Volume= 0.121 af, Depth= 2.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.13"

Area (ac)	CN	Description
0.100	98	Paved parking, HSG A
0.620	39	>75% Grass cover, Good, HSG A
0.720	47	Weighted Average
0.620		86.11% Pervious Area
0.100		13.89% Impervious Area

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Type III 24-hr 100-Year Rainfall=8.13"

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

Summary for Subcatchment P-4:

Runoff = 0.27 cfs @ 12.33 hrs, Volume= 0.056 af, Depth= 0.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.13"

Area (ac)	CN	Description
0.300	39	>75% Grass cover, Good, HSG A
0.820	30	Woods, Good, HSG A
1.120	32	Weighted Average
1.120		100.00% Pervious Area

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

Summary for Reach 1R: SWALE

Inflow Area = 0.520 ac, 1.92% Impervious, Inflow Depth = 1.03" for 100-Year event
 Inflow = 0.37 cfs @ 12.12 hrs, Volume= 0.044 af
 Outflow = 0.19 cfs @ 12.90 hrs, Volume= 0.044 af, Atten= 49%, Lag= 46.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
 Max. Velocity= 0.21 fps, Min. Travel Time= 25.1 min
 Avg. Velocity = 0.07 fps, Avg. Travel Time= 75.0 min

Peak Storage= 282 cf @ 12.48 hrs
 Average Depth at Peak Storage= 0.14'
 Bank-Full Depth= 1.00' Flow Area= 9.0 sf, Capacity= 5.81 cfs

6.00' x 1.00' deep channel, n= 0.150 Sheet flow over Short Grass
 Side Slope Z-value= 3.0 ' Top Width= 12.00'
 Length= 310.0' Slope= 0.0065 ' / '
 Inlet Invert= 124.00', Outlet Invert= 122.00'



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Type III 24-hr 100-Year Rainfall=8.13"

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Summary for Reach DP-1: DESIGN POINT 1

Inflow Area = 2.640 ac, 14.77% Impervious, Inflow Depth = 0.94" for 100-Year event
 Inflow = 1.56 cfs @ 12.10 hrs, Volume= 0.208 af
 Outflow = 1.56 cfs @ 12.10 hrs, Volume= 0.208 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond 1P: INFILTRATION BASIN

Used more restrictive B layer

Inflow Area = 0.280 ac, 100.00% Impervious, Inflow Depth = 7.89" for 100-Year event
 Inflow = 2.25 cfs @ 12.07 hrs, Volume= 0.184 af
 Outflow = 0.10 cfs @ 14.38 hrs, Volume= 0.184 af, Atten= 95%, Lag= 138.7 min
 Discarded = 0.10 cfs @ 14.38 hrs, Volume= 0.184 af
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
 Peak Elev= 121.48' @ 14.38 hrs Surf.Area= 1,870 sf Storage= 5,064 cf

Plug-Flow detention time= 653.9 min calculated for 0.184 af (100% of inflow)
 Center-of-Mass det. time= 654.9 min (1,395.0 - 740.1)

Volume	Invert	Avail.Storage	Storage Description
#1	113.00'	8,519 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
113.00	17	0	0
114.00	59	38	38
115.00	126	93	131
116.00	219	173	303
117.00	336	278	581
118.00	517	427	1,007
119.00	694	606	1,613
120.00	1,387	1,041	2,653
121.00	1,705	1,546	4,199
122.00	2,047	1,876	6,075
123.00	2,840	2,444	8,519

Device	Routing	Invert	Outlet Devices
#1	Primary	122.00'	30.0' long x 3.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 Coef. (English) 2.44 2.58 2.68 2.67 2.65 2.64 2.64 2.68 2.68 2.72 2.81 2.92 2.97 3.07 3.32
#2	Discarded	113.00'	2.410 in/hr Exfiltration over Surface area

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Discarded OutFlow Max=0.10 cfs @ 14.38 hrs HW=121.48' (Free Discharge)

↑**2=Exfiltration** (Exfiltration Controls 0.10 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=113.00' (Free Discharge)

↑**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 2P: LEACHING CATCH BASIN (FRENCH DRAIN)

Inflow Area = 0.720 ac, 13.89% Impervious, Inflow Depth = 2.01" for 100-Year event
 Inflow = 1.52 cfs @ 12.09 hrs, Volume= 0.121 af
 Outflow = 1.49 cfs @ 12.09 hrs, Volume= 0.120 af, Atten= 2%, Lag= 0.0 min
 Discarded = 0.01 cfs @ 25.62 hrs, Volume= 0.013 af
 Primary = 1.48 cfs @ 12.09 hrs, Volume= 0.107 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs / 2
 Peak Elev= 120.54' @ 12.09 hrs Surf.Area= 0.003 ac Storage= 0.005 af

Plug-Flow detention time= 39.7 min calculated for 0.120 af (100% of inflow)
 Center-of-Mass det. time= 37.7 min (915.2 - 877.5)

Volume	Invert	Avail.Storage	Storage Description
#1	119.00'	0.008 af	36.0" W x 36.0" H Box Pipe Storage/Trenches x 2 L= 20.0'
#2	119.00'	0.001 af	18.0" Round Pipe Storage L= 18.0' S= 0.0500 '/'
		0.009 af	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	120.50'	72.0" x 120.0" Horiz. Orifice/Grate X 2.00 C= 0.600 Limited to weir flow at low heads
#2	Discarded	119.00'	2.410 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.01 cfs @ 25.62 hrs HW=120.20' (Free Discharge)

↑**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=1.40 cfs @ 12.09 hrs HW=120.54' (Free Discharge)

↑**1=Orifice/Grate** (Weir Controls 1.40 cfs @ 0.62 fps)