STORMWATER MANAGEMENT REPORT

Beaver Brook Farm
Off Adams Street
Holliston, Massachusetts

March 7, 2023
Revised: June 29, 2023

Prepared for:

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Project Introduction:

The applicant, Dennis Farreira, is proposing to develop a seven (7) lot single family Open Space Residential Subdivision located off Adams Street in Holliston, Massachusetts. The existing property consist of approximately 33.95 acres of land area. This existing site is partially developed with two single family dwellings, horse barn, indoor area, several accessory structures and outdoor grassed paddocks. The proposal is to raze the existing horse barn, indoor arena and associated accessory structures. The two existing dwellings will remain. The house in front will remain within the proposed Lot 1 and the other will be located within Lot 6.

The Project will be serviced by town water, onsite sewage disposal systems and other available public utilities. The stormwater generated from the Project will be captured, conveyed, treated and mitigated on-site utilizing Best Management Practices.

The purpose of these calculations is to demonstrate design compliance of the Project's stormwater management system for water quality and quantity, specifically post-development peak discharge rates per the DEP's Stormwater Management Policy, the Town of Holliston Land Subdivision Regulations. As designed, the system will mitigate peak rates of runoff for storms up to and including the 100-year event under post-construction conditions.

Methodology/Sources of Data:

The pre- and post-development drainage calculations were prepared in compliance with the performance standards and requirements of the 2008 Massachusetss Stormwater Handbook. The calculations of runoff volumes and peak rates required under Massachusetts Stormwater Management Standard 2 are based on precipitation data provided in National Oceanic and Atmospheric Administration (NOAA) -National Weather Service "NOAA Atlas 14".

The overall storm water management plan for the project is designed to maintain the peak rate of storm water runoff and runoff volumes from the site after development. The Soil Conservation Service Modified Soil Cover Complex Method, the computer program "HydroCAD" by Applied Microcomputer Systems, and the procedures specified in Urban Hydrology for storm Small Watersheds were used to determine pre-and post-developed peak flow rates of runoff from the site. The 2-year, 10-year, 25-year, 50-year and 100-year storm events have been utilized for hydrology calculations. The rainfall data for the Type III, 24-hour storm events are as follows:

24-Hour Storm	Rainfall (inches)
2	3.36
10	5.25
25	6.43
50	7.30
100	8.25

The storm water runoff will be controlled through the use of "Best Management Practices" and in conformance with the MADEP Stormwater Management Policy. The proposed Project will result in an improvement over the existing conditions, by constructing a storm water management system that will provide treatment, groundwater recharge and reduce the peak rates of runoff and offsite runoff volumes.

The piped drainage system has been designed utilizing the Rational Method for the 25 year storm event to size street drains.

Soils:

The Natural Resources Conservation Service (NRCS), Hydrologic Soils Group Map for Middlesex county, Massachusetts indicates that the on-site soils in the area of proposed development consist of Haven Silt Loam-251B. NRCS assigned an 'A' hydrologic soil group rating for these soils. On-site soil testing was performed to determine groundwater elevations and confirm soil classifications (See Soil Logs Appendix F).

The soils are classified as Hydrologic Group A, Sand. The Rawles Rate of 8.27 inches/hour was used in the calculations. (See Table)

Table 2.3.3. 1982 Rawls Rates

Texture Class	NRCS Hydrologic Soil Group (HSG)	Infiltration Rate Inches/Hour
Sand	A	8.27
Loamy Sand	A	2.41
Sandy Loam	B	1.02
Loam	B	0.52
Silt Loam	C	0.27
Sandy Clay Loam	C	0.17
Clay Loam	D	0.09
Silty Clay Loam	D	0.06
Sandy Clay	D	0.05
Silty Clay	D	0.04
Clay	D	0.02

Existing Conditions Overview:

The Project is located off Adams Street and identified as Assessor Map 4, Block 2, Lot 58 containing approximately 33.95 +/- acres. The front portion of the site along Adams Street is approximately thirteen (13) acres of developed area. The developed portion is a active horse farm with two single family dwellings on the property. The horse farm includes indoor and outdoor arenas, barn, several grassed paddocks and some small accessory buildings. There is a existing pond centrally located in the front portion of the property that was manmade by the current owners when they developed the farm. The pond has a 15 inch culvert that discharges under the existing driveway. The culvert acts as a control outlet for the existing conditions.

The rear portion of property is undeveloped woodlands and fields, with several connecting trails to the Town of Holliston Adams Street Conservation Area.

The stormwater design is for the front portion of the property, which is the area of development. The rear portion of the property will be designated open space and no development will occur. The existing runoff from the area has several subcatchments and the existing pond modeled with the 15 inch outlet pipe. The overall runoff discharges towards the southern property boundary of the site Design Point #1 (Link DP1).

Proposed Conditions Overview:

The proposal is to subdivide the property as an Open Space Residential Subdivision consisting of seven (7) single family dwellings. The proposal is to raze the existing horse barn, indoor arena and associated accessory structures. The two existing dwellings will remain. The house in front will remain within the proposed Lot 1 and the other will be located within Lot 6.

The proposed roadway extends from Adams Street into the property and loops around the existing pond back to the proposed road. The proposed stormwater drainage system is designed to capture and treat the runoff utilizing catch basins, manholes, drainage basins and proprietary treatment units. The roof runoff from the proposed dwellings will be conveyed via gutters and downspouts to underground recharge systems, that are sized to mitigate the 100 year storm event.

The proposed runoff areas have been divided into several subcatchments. The existing pond has been modeled with the same 15" outlet pipe. The proposed systems will reduce all post-development flow rates and volumes of runoff up to and including the 100-year event. The overall runoff discharges towards the southern property boundary (Design Point #1). The peak flows and volumes of runoff have been compared at Design Point #1. (Link DP2)

The following is summary comparison of Pre- and Post-Developed Rates and Volumes of Runoff (Design Pt #1):

Summary of Peak Stormwater Runoff Rates:										
Design Point	2-Yr Peak Flow (cfs)		10-Yr Peak Flow (cfs)		25-Yr Peak Flow (cfs)		50-Yr Peak Flow (cfs)		100-Yr Peak Flow (cfs)	
	Exist	*Prop.*	*Exist*	*Prop*	*Exist*	*Prop*	*Exist*	*Prop*	*Exist*	*Prop.*
DP1/ DP2	0.52	0.09	4.31	2.36	8.60	5.83	12.41	9.28	17.35	13.89

Summary of Peak Stormwater Runoff Volumes:										
Design Point	2-Yr Peak Flow (cu.ft.)		10-Yr Peak Flow (cu.ft.)		25-Yr Peak Flow (cu.ft.)		50-Yr Peak Flow (cu.ft.)		100-Yr Peak Flow (cu.ft.)	
	Exist	*Prop*	*Exist*	*Prop*	*Exist*	*Prop*	*Exist*	*Prop.*	*Exist.*	*Prop.*
DP1/ DP2	5,764	2,594	30,319	22,911	54,209	42,973	74,579	61,145	99,014	83,221

The following is a summary of the Recharge Basin (2P):

Summary of Recharge Basin										
Design Point	2-Yr Storm Event		10-Yr Storm Event		25-Yr Storm Event		50-Yr Storm Event		100-Yr Storm Event	
	Peak Elev.Ft.	*Out-flow (cfs)*	*Peak Elev. Ft.*	*Out-flow (cfs)*	*Peak Elev.Ft.*	*Out-flow (cfs)*	*Peak Elev.Ft.*	*Out-flow (cfs)*	*Peak Elev.Ft.*	*Out-flow (cfs)*
2P	268.06	0.00	269.67	0.00	270.49	0.65	270.91	1.18	271.49	1.81

The following is a Comparison of the Existing Pond (1P/3P):

Summary of Existing Pond										
Design Point	**2-Yr Storm Event**		**10-Yr Storm Event**		**25-Yr Storm Event**		**50-Yr Storm Event**		**100-Yr Storm Event**	
	Peak Elev. Ft.	***Out-flow (cfs)***	***Peak Elev. Ft.***	***Out-flow (cfs)***	***Peak Elev. Ft.***	***Out-Flow (cfs)***	***Peak Elev. Ft.***	***Out-flow (cfs)***	***Peak Elev. Ft.***	***Out-flow (cfs)***
Pre Dev 1P	265.65	0.00	266.00	0.18	266.15	0.51	266.32	1.02	266.55	1.91
Post Dev 3P	265.85	0.01	266.03	0.23	266.27	0.87	266.51	1.75	266.74	2.74

Summary:

The calculations performed for all design storm events indicate that the total peak rates and volumes of runoff for the Project as proposed will not exceed those of existing conditions with the implementation of the stormwater management system. With the implementation of the stormwater management system as designed, along with the Operation and Maintenance plan contained herein, all of the objectives of the DEP's Stormwater Management Regulations are satisfied.

NOAA Atlas 14, Volume 10, Version 3 ASHLAND
Station ID: 19-0218
Location name: Ashland, Massachusetts, USA*
Latitude: 42.25°, Longitude: -71.4667°
Elevation:
Elevation (station metadata): 230 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.334** (0.260-0.426)	**0.401** (0.312-0.513)	**0.511** (0.397-0.656)	**0.603** (0.465-0.777)	**0.729** (0.544-0.981)	**0.823** (0.602-1.13)	**0.922** (0.656-1.32)	**1.03** (0.696-1.51)	**1.19** (0.774-1.80)	**1.32** (0.838-2.04)
10-min	**0.473** (0.369-0.604)	**0.568** (0.443-0.726)	**0.724** (0.562-0.929)	**0.854** (0.659-1.10)	**1.03** (0.771-1.39)	**1.17** (0.854-1.60)	**1.31** (0.929-1.86)	**1.46** (0.987-2.14)	**1.69** (1.10-2.55)	**1.88** (1.19-2.89)
15-min	**0.556** (0.434-0.710)	**0.669** (0.521-0.854)	**0.853** (0.662-1.09)	**1.00** (0.775-1.30)	**1.21** (0.907-1.64)	**1.37** (1.00-1.89)	**1.54** (1.09-2.19)	**1.72** (1.16-2.51)	**1.99** (1.29-3.00)	**2.21** (1.40-3.40)
30-min	**0.763** (0.595-0.974)	**0.917** (0.714-1.17)	**1.17** (0.906-1.50)	**1.38** (1.06-1.78)	**1.66** (1.24-2.24)	**1.88** (1.38-2.59)	**2.11** (1.50-3.00)	**2.36** (1.59-3.44)	**2.72** (1.76-4.11)	**3.02** (1.91-4.65)
60-min	**0.969** (0.756-1.24)	**1.16** (0.907-1.49)	**1.48** (1.15-1.90)	**1.75** (1.35-2.25)	**2.11** (1.58-2.84)	**2.39** (1.75-3.28)	**2.68** (1.90-3.82)	**3.00** (2.02-4.37)	**3.45** (2.24-5.22)	**3.83** (2.42-5.90)
2-hr	**1.23** (0.966-1.56)	**1.49** (1.17-1.89)	**1.91** (1.49-2.43)	**2.25** (1.75-2.88)	**2.73** (2.06-3.67)	**3.09** (2.28-4.24)	**3.47** (2.50-4.96)	**3.92** (2.65-5.69)	**4.61** (3.00-6.92)	**5.19** (3.30-7.95)
3-hr	**1.42** (1.12-1.79)	**1.72** (1.35-2.17)	**2.21** (1.73-2.80)	**2.61** (2.04-3.33)	**3.17** (2.40-4.25)	**3.58** (2.66-4.92)	**4.03** (2.92-5.78)	**4.58** (3.10-6.63)	**5.43** (3.53-8.12)	**6.15** (3.91-9.38)
6-hr	**1.82** (1.44-2.28)	**2.20** (1.75-2.77)	**2.84** (2.24-3.58)	**3.37** (2.64-4.27)	**4.10** (3.12-5.46)	**4.64** (3.46-6.33)	**5.22** (3.81-7.44)	**5.95** (4.04-8.54)	**7.08** (4.62-10.5)	**8.06** (5.14-12.2)
12-hr	**2.30** (1.84-2.87)	**2.80** (2.24-3.50)	**3.62** (2.88-4.54)	**4.30** (3.40-5.42)	**5.24** (4.02-6.93)	**5.93** (4.46-8.04)	**6.69** (4.90-9.46)	**7.62** (5.20-10.9)	**9.05** (5.93-13.4)	**10.3** (6.59-15.5)
24-hr	**2.73** (2.20-3.38)	**3.36** (2.70-4.17)	**4.40** (3.52-5.46)	**5.25** (4.18-6.56)	**6.43** (4.96-8.46)	**7.30** (5.52-9.84)	**8.25** (6.08-11.6)	**9.43** (6.46-13.4)	**11.3** (7.41-16.5)	**12.9** (8.27-19.2)
2-day	**3.04** (2.46-3.73)	**3.80** (3.07-4.67)	**5.04** (4.06-6.22)	**6.07** (4.86-7.53)	**7.49** (5.82-9.81)	**8.52** (6.50-11.5)	**9.67** (7.20-13.6)	**11.1** (7.66-15.7)	**13.5** (8.89-19.6)	**15.6** (10.0-23.1)
3-day	**3.28** (2.67-4.02)	**4.10** (3.32-5.02)	**5.42** (4.38-6.66)	**6.52** (5.24-8.06)	**8.03** (6.26-10.5)	**9.14** (6.99-12.2)	**10.4** (7.74-14.5)	**11.9** (8.23-16.7)	**14.5** (9.55-21.0)	**16.7** (10.8-24.6)
4-day	**3.52** (2.87-4.30)	**4.36** (3.55-5.33)	**5.73** (4.65-7.03)	**6.87** (5.54-8.47)	**8.44** (6.59-11.0)	**9.58** (7.34-12.8)	**10.9** (8.11-15.1)	**12.5** (8.61-17.4)	**15.0** (9.95-21.7)	**17.3** (11.2-25.5)
7-day	**4.22** (3.46-5.12)	**5.10** (4.18-6.20)	**6.55** (5.34-7.98)	**7.75** (6.28-9.50)	**9.41** (7.38-12.1)	**10.6** (8.16-14.0)	**12.0** (8.93-16.5)	**13.6** (9.44-18.9)	**16.2** (10.7-23.2)	**18.4** (11.9-26.9)
10-day	**4.89** (4.02-5.91)	**5.80** (4.77-7.02)	**7.30** (5.98-8.87)	**8.55** (6.95-10.4)	**10.3** (8.06-13.1)	**11.5** (8.86-15.1)	**12.9** (9.61-17.6)	**14.5** (10.1-20.1)	**17.1** (11.4-24.4)	**19.2** (12.4-28.0)
20-day	**6.89** (5.71-8.27)	**7.87** (6.51-9.46)	**9.48** (7.81-11.4)	**10.8** (8.85-13.1)	**12.6** (9.97-16.0)	**14.0** (10.8-18.1)	**15.5** (11.5-20.7)	**17.1** (12.0-23.4)	**19.4** (13.0-27.5)	**21.2** (13.8-30.8)
30-day	**8.53** (7.09-10.2)	**9.55** (7.93-11.4)	**11.2** (9.29-13.5)	**12.6** (10.4-15.2)	**14.5** (11.5-18.2)	**16.0** (12.3-20.4)	**17.5** (12.9-23.1)	**19.0** (13.4-25.9)	**21.1** (14.2-29.8)	**22.7** (14.8-32.8)
45-day	**10.5** (8.80-12.5)	**11.6** (9.68-13.8)	**13.3** (11.1-16.0)	**14.8** (12.2-17.8)	**16.8** (13.3-20.9)	**18.3** (14.1-23.2)	**19.8** (14.6-25.9)	**21.3** (15.0-28.9)	**23.1** (15.6-32.5)	**24.5** (16.0-35.1)
60-day	**12.2** (10.2-14.5)	**13.3** (11.1-15.8)	**15.1** (12.6-18.0)	**16.6** (13.7-19.9)	**18.6** (14.8-23.0)	**20.2** (15.6-25.5)	**21.7** (16.0-28.1)	**23.1** (16.3-31.2)	**24.8** (16.7-34.6)	**25.8** (16.9-37.0)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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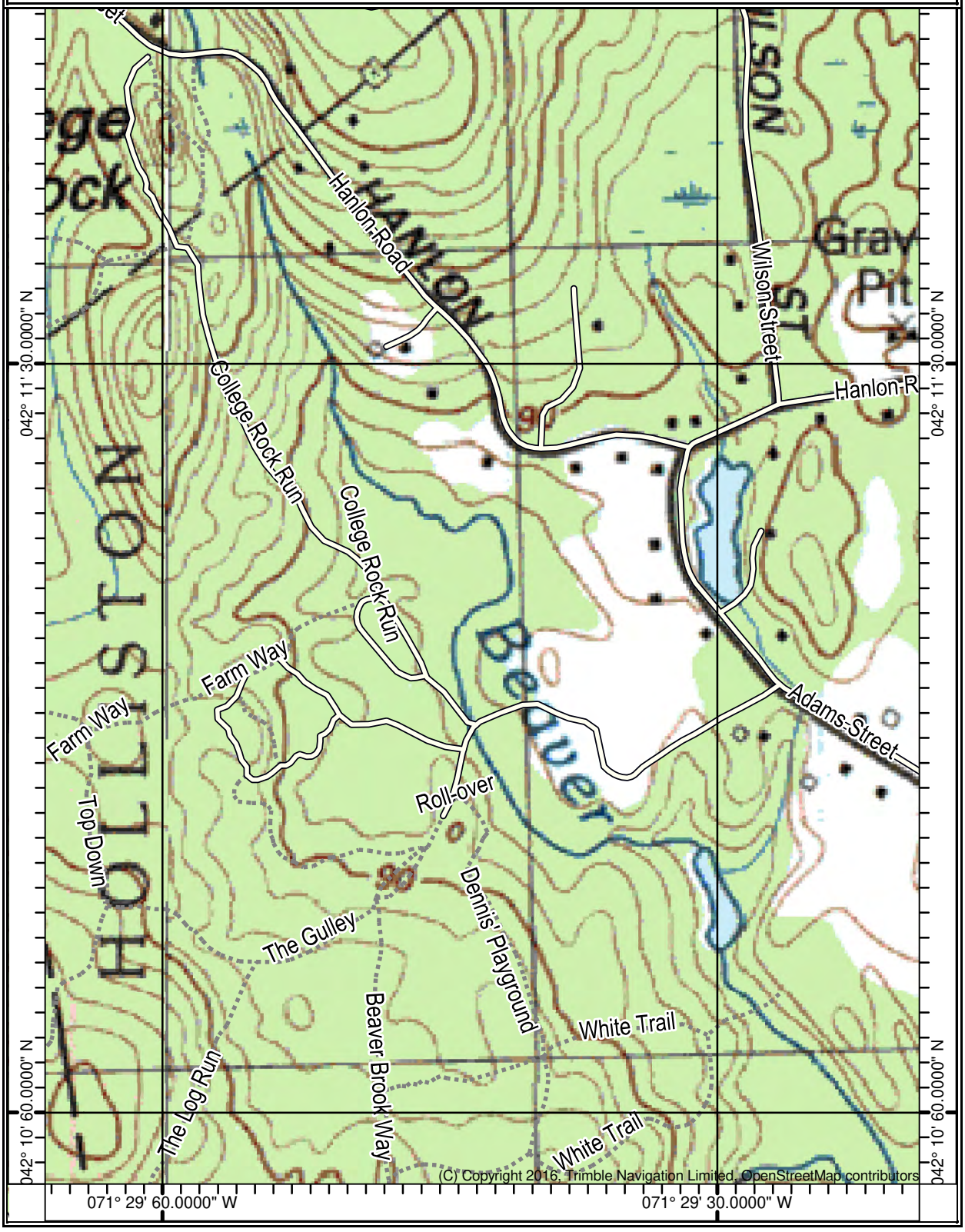
PF graphical

Map Name: MEDFIELD
Print Date: 02/08/23

Scale: 1 inch = 600 ft.
Map Center: 042° 11' 21.3032" N,

Horizontal Datum: NAD27



SCALE 1:7200

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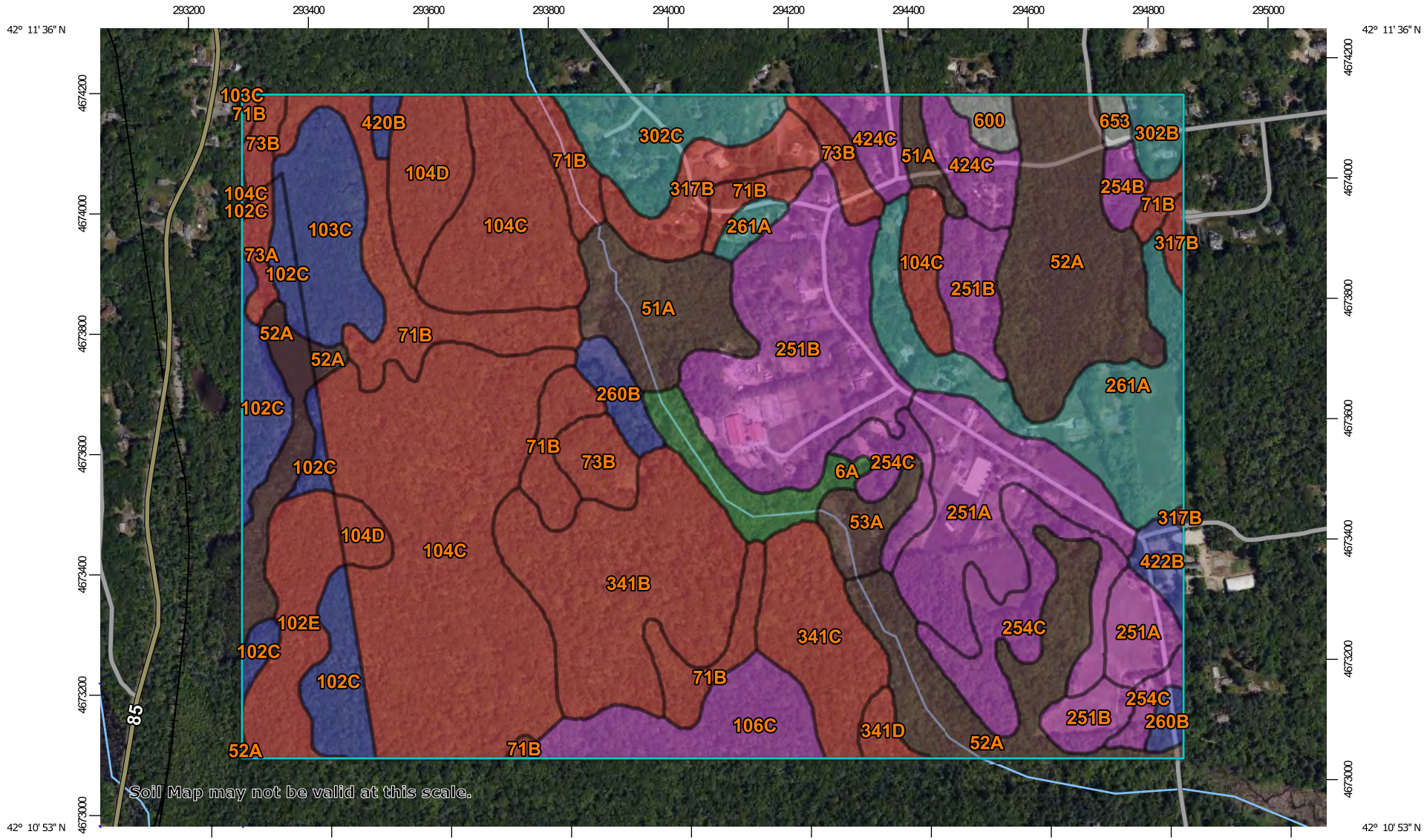
Feet

Hydrologic Soil Group—Middlesex County, Massachusetts; and Worcester County, Massachusetts, Southern Part
(Adams Street)



Map Scale: 1:9,350 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 100 200 400 600

Feet
0 450 900 1800 2700

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

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

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 Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 15, Sep 9, 2022

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
6A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	A/D	6.5	1.5%
51A	Swansea muck, 0 to 1 percent slopes	B/D	14.3	3.3%
52A	Freetown muck, 0 to 1 percent slopes	B/D	40.7	9.5%
53A	Freetown muck, ponded, 0 to 1 percent slopes	B/D	4.2	1.0%
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	D	29.7	6.9%
73B	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	9.0	2.1%
103C	Charlton-Hollis-Rock outcrop complex, 8 to 15 percent slopes	B	11.2	2.6%
104C	Hollis-Rock outcrop-Charlton complex, 0 to 15 percent slopes	D	70.3	16.4%
104D	Hollis-Rock outcrop-Charlton complex, 15 to 25 percent slopes	D	9.9	2.3%
106C	Narragansett-Hollis-Rock outcrop complex, 3 to 15 percent slopes	A	11.3	2.6%
251A	Haven silt loam, 0 to 3 percent slopes	A	23.2	5.4%
251B	Haven silt loam, 3 to 8 percent slopes	A	37.8	8.8%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	A	2.1	0.5%
254C	Merrimac fine sandy loam, 8 to 15 percent slopes	A	18.1	4.2%
260B	Sudbury fine sandy loam, 3 to 8 percent slopes	B	4.5	1.1%
261A	Tisbury silt loam, 0 to 3 percent slopes	C	22.3	5.2%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
302B	Montauk fine sandy loam, 0 to 8 percent slopes, extremely stony	C	2.9	0.7%
302C	Montauk fine sandy loam, 8 to 15 percent slopes, extremely stony	C	10.4	2.4%
317B	Scituate fine sandy loam, 3 to 8 percent slopes, extremely stony	D	9.2	2.1%
341B	Broadbrook very fine sandy loam, 3 to 8 percent slopes, very stony	D	28.0	6.5%
341C	Broadbrook very fine sandy loam, 8 to 15 percent slopes, very stony	D	12.5	2.9%
341D	Broadbrook very fine sandy loam, 15 to 25 percent slopes, very stony	D	1.7	0.4%
420B	Canton fine sandy loam, 3 to 8 percent slopes	B	0.9	0.2%
422B	Canton fine sandy loam, 0 to 8 percent slopes, extremely stony	B	2.6	0.6%
424C	Canton fine sandy loam, 8 to 15 percent slopes, extremely bouldery	A	8.8	2.0%
600	Pits, gravel		1.9	0.4%
653	Udorthents, sandy		1.0	0.2%
Subtotals for Soil Survey Area			**395.1**	**91.9%**
Totals for Area of Interest			**429.8**	**100.0%**

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
52A	Freetown muck, 0 to 1 percent slopes	B/D	6.4	1.5%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	2.1	0.5%
102C	Chatfield-Hollis-Rock outcrop complex, 0 to 15 percent slopes	B	15.3	3.6%
102E	Chatfield-Hollis-Rock outcrop complex, 15 to 35 percent slopes	D	10.9	2.5%

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
Subtotals for Soil Survey Area			**34.7**	**8.1%**
Totals for Area of Interest			**429.8**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

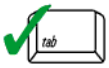
Tie-break Rule: Higher

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

Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

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

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

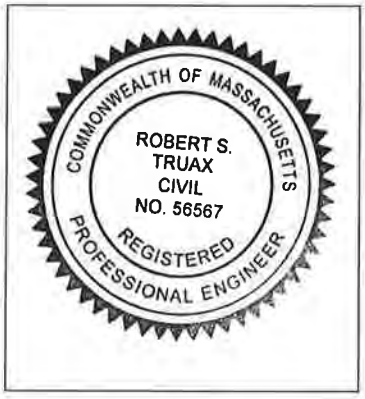
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



Signature and Date 3/7/23

Checklist

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

☐ New development

☐ Redevelopment

☒ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

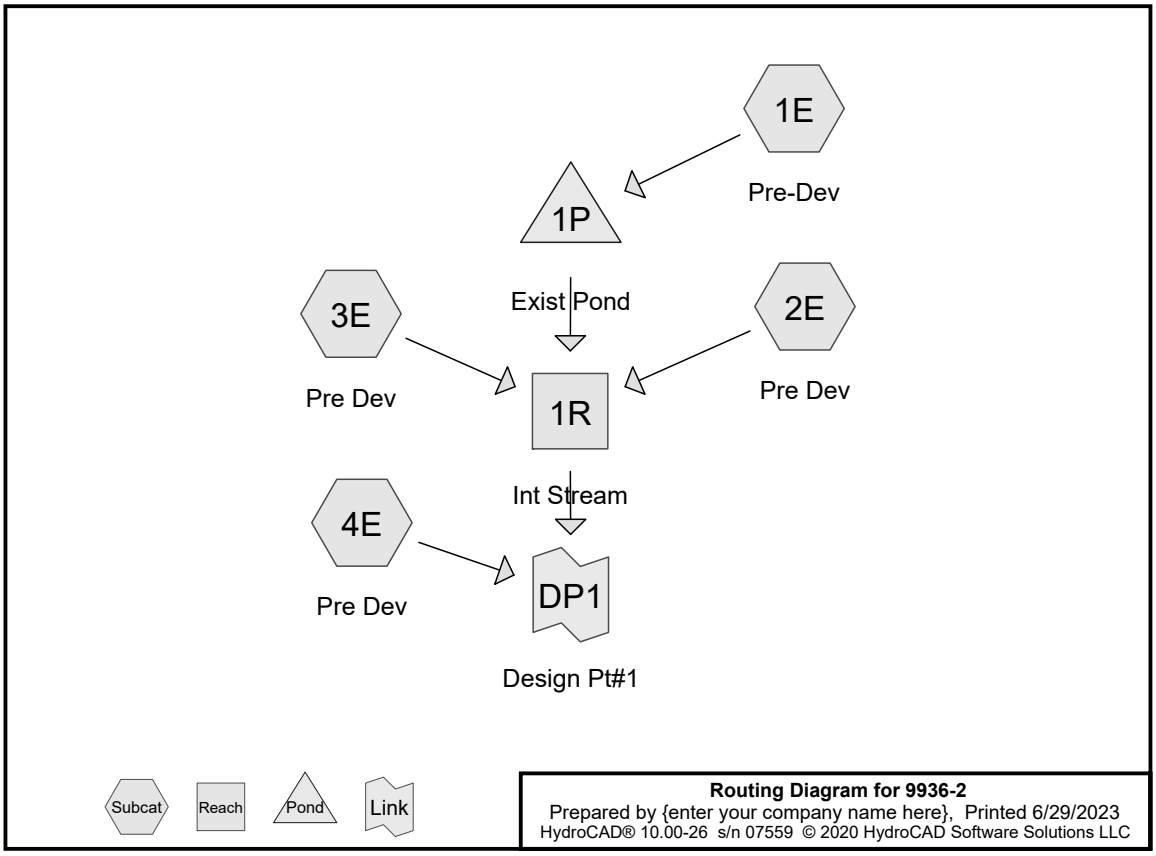
☒ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

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

APPENDIX – A1

Hydrogeological Calculations for Pre-Development
HyrdoCAD

Standard 2



Summary for Subcatchment 1E: Pre-Dev

Runoff = 0.04 cfs @ 14.77 hrs, Volume= 1,097 cf, Depth> 0.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
	4,587	98	Roofs, HSG A
*	7,844	98	Imp, Drives/Patio, HSG A
	144,139	39	>75% Grass cover, Good, HSG A
*	8,160	98	Pond
	164,730	46	Weighted Average
	144,139		87.50% Pervious Area
	20,591		12.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	275	Total			

Summary for Subcatchment 2E: Pre Dev

Runoff = 0.01 cfs @ 15.76 hrs, Volume= 282 cf, Depth> 0.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
*	1,190	98	Paved, HSG A
	23,020	30	Woods, Good, HSG A
	58,243	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	95,575	43	Weighted Average
	94,385		98.75% Pervious Area
	1,190		1.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.1	270	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.7	370	Total			

Summary for Subcatchment 3E: Pre Dev

Runoff = 0.02 cfs @ 13.70 hrs, Volume= 566 cf, Depth> 0.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
*	930	98	Roofs, HSG A
	4,145	98	Paved , HSG A
	11,350	30	Woods, Good, HSG A
	33,467	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	57,732	48	Weighted Average
	52,657		91.21% Pervious Area
	5,075		8.79% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.2	240	0.0700	1.85		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
10.4	290	Total			

Summary for Subcatchment 4E: Pre Dev

Runoff = 0.51 cfs @ 12.48 hrs, Volume= 4,927 cf, Depth> 0.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
	24,014	98	Roofs, HSG A
	2,763	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
	20,740	76	Gravel roads, HSG A
*	27,786	78	Wetlands
	133,237	39	>75% Grass cover, Good, HSG A
	220,832	54	Weighted Average
	194,055		87.87% Pervious Area
	26,777		12.13% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
5.2	270	0.0150	0.86		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
2.4	210	0.0450	1.48		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.8	530	Total			

Summary for Reach 1R: Int Stream

Inflow Area = 318,037 sf, 8.44% Impervious, Inflow Depth > 0.03" for 2-year event
Inflow = 0.03 cfs @ 15.13 hrs, Volume= 848 cf
Outflow = 0.03 cfs @ 15.28 hrs, Volume= 838 cf, Atten= 0%, Lag= 9.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.79 fps, Min. Travel Time= 5.8 min
Avg. Velocity = 0.70 fps, Avg. Travel Time= 6.6 min

Peak Storage= 10 cf @ 15.19 hrs
Average Depth at Peak Storage= 0.02'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 1P: Exist Pond

Inflow Area = 164,730 sf, 12.50% Impervious, Inflow Depth > 0.08" for 2-year event
Inflow = 0.04 cfs @ 14.77 hrs, Volume= 1,097 cf
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 265.65' @ 24.00 hrs Surf.Area= 7,513 sf Storage= 1,095 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=265.50' (Free Discharge)
1=Culvert (Controls 0.00 cfs)

Summary for Link DP1: Design Pt#1

Inflow Area = 538,869 sf, 9.95% Impervious, Inflow Depth > 0.13" for 2-year event
Inflow = 0.52 cfs @ 12.48 hrs, Volume= 5,764 cf
Primary = 0.52 cfs @ 12.48 hrs, Volume= 5,764 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1E: Pre-Dev

Runoff = 1.13 cfs @ 12.22 hrs, Volume= 7,875 cf, Depth> 0.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

	Area (sf)	CN	Description
	4,587	98	Roofs, HSG A
*	7,844	98	Imp, Drives/Patio, HSG A
	144,139	39	>75% Grass cover, Good, HSG A
*	8,160	98	Pond
	164,730	46	Weighted Average
	144,139		87.50% Pervious Area
	20,591		12.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	275	Total			

Summary for Subcatchment 2E: Pre Dev

Runoff = 0.36 cfs @ 12.46 hrs, Volume= 3,371 cf, Depth> 0.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

	Area (sf)	CN	Description
*	1,190	98	Paved, HSG A
	23,020	30	Woods, Good, HSG A
	58,243	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	95,575	43	Weighted Average
	94,385		98.75% Pervious Area
	1,190		1.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.1	270	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.7	370	Total			

Summary for Subcatchment 3E: Pre Dev

Runoff = 0.53 cfs @ 12.22 hrs, Volume= 3,275 cf, Depth> 0.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

	Area (sf)	CN	Description
*	930	98	Roofs, HSG A
	4,145	98	Paved , HSG A
	11,350	30	Woods, Good, HSG A
	33,467	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	57,732	48	Weighted Average
	52,657		91.21% Pervious Area
	5,075		8.79% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.2	240	0.0700	1.85		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
10.4	290	Total			

Summary for Subcatchment 4E: Pre Dev

Runoff = 3.64 cfs @ 12.27 hrs, Volume= 19,091 cf, Depth> 1.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

	Area (sf)	CN	Description
	24,014	98	Roofs, HSG A
	2,763	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
	20,740	76	Gravel roads, HSG A
*	27,786	78	Wetlands
	133,237	39	>75% Grass cover, Good, HSG A
	220,832	54	Weighted Average
	194,055		87.87% Pervious Area
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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
5.2	270	0.0150	0.86		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
2.4	210	0.0450	1.48		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.8	530	Total			

Summary for Reach 1R: Int Stream

Inflow Area = 318,037 sf, 8.44% Impervious, Inflow Depth > 0.43" for 10-year event
Inflow = 0.80 cfs @ 12.38 hrs, Volume= 11,268 cf
Outflow = 0.80 cfs @ 12.43 hrs, Volume= 11,228 cf, Atten= 1%, Lag= 2.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.65 fps, Min. Travel Time= 1.7 min
Avg. Velocity = 1.73 fps, Avg. Travel Time= 2.7 min

Peak Storage= 83 cf @ 12.40 hrs
Average Depth at Peak Storage= 0.13'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 1P: Exist Pond

Inflow Area = 164,730 sf, 12.50% Impervious, Inflow Depth > 0.57" for 10-year event
Inflow = 1.13 cfs @ 12.22 hrs, Volume= 7,875 cf
Outflow = 0.18 cfs @ 15.74 hrs, Volume= 4,622 cf, Atten= 84%, Lag= 211.5 min
Primary = 0.18 cfs @ 15.74 hrs, Volume= 4,622 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.00' @ 15.74 hrs Surf.Area= 7,986 sf Storage= 3,838 cf

Plug-Flow detention time= 297.6 min calculated for 4,612 cf (59% of inflow)

Center-of-Mass det. time= 158.2 min (1,089.6 - 931.4)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=0.18 cfs @ 15.74 hrs HW=266.00' (Free Discharge)
1=Culvert (Barrel Controls 0.18 cfs @ 2.13 fps)

Summary for Link DP1: Design Pt#1

Inflow Area = 538,869 sf, 9.95% Impervious, Inflow Depth > 0.68" for 10-year event
Inflow = 4.31 cfs @ 12.28 hrs, Volume= 30,319 cf
Primary = 4.31 cfs @ 12.28 hrs, Volume= 30,319 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1E: Pre-Dev

Runoff = 3.05 cfs @ 12.15 hrs, Volume= 14,425 cf, Depth> 1.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

	Area (sf)	CN	Description
	4,587	98	Roofs, HSG A
*	7,844	98	Imp, Drives/Patio, HSG A
	144,139	39	>75% Grass cover, Good, HSG A
*	8,160	98	Pond
	164,730	46	Weighted Average
	144,139		87.50% Pervious Area
	20,591		12.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	275	Total			

Summary for Subcatchment 2E: Pre Dev

Runoff = 0.99 cfs @ 12.32 hrs, Volume= 6,641 cf, Depth> 0.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

	Area (sf)	CN	Description
*	1,190	98	Paved, HSG A
	23,020	30	Woods, Good, HSG A
	58,243	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	95,575	43	Weighted Average
	94,385		98.75% Pervious Area
	1,190		1.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.1	270	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.7	370	Total			

Summary for Subcatchment 3E: Pre Dev

Runoff = 1.22 cfs @ 12.18 hrs, Volume= 5,775 cf, Depth> 1.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

	Area (sf)	CN	Description
*	930	98	Roofs, HSG A
	4,145	98	Paved , HSG A
	11,350	30	Woods, Good, HSG A
	33,467	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	57,732	48	Weighted Average
	52,657		91.21% Pervious Area
	5,075		8.79% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.2	240	0.0700	1.85		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
10.4	290	Total			

Summary for Subcatchment 4E: Pre Dev

Runoff = 6.57 cfs @ 12.25 hrs, Volume= 30,905 cf, Depth> 1.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

	Area (sf)	CN	Description
	24,014	98	Roofs, HSG A
	2,763	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
	20,740	76	Gravel roads, HSG A
*	27,786	78	Wetlands
	133,237	39	>75% Grass cover, Good, HSG A
	220,832	54	Weighted Average
	194,055		87.87% Pervious Area
	26,777		12.13% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
5.2	270	0.0150	0.86		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
2.4	210	0.0450	1.48		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.8	530	Total			

Summary for Reach 1R: Int Stream

Inflow Area = 318,037 sf, 8.44% Impervious, Inflow Depth > 0.88" for 25-year event
Inflow = 2.05 cfs @ 12.24 hrs, Volume= 23,353 cf
Outflow = 2.03 cfs @ 12.29 hrs, Volume= 23,304 cf, Atten= 1%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.63 fps, Min. Travel Time= 1.3 min
Avg. Velocity = 2.16 fps, Avg. Travel Time= 2.1 min

Peak Storage= 156 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.23'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 1P: Exist Pond

Inflow Area = 164,730 sf, 12.50% Impervious, Inflow Depth > 1.05" for 25-year event
Inflow = 3.05 cfs @ 12.15 hrs, Volume= 14,425 cf
Outflow = 0.51 cfs @ 13.62 hrs, Volume= 10,937 cf, Atten= 83%, Lag= 88.0 min
Primary = 0.51 cfs @ 13.62 hrs, Volume= 10,937 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.15' @ 13.62 hrs Surf.Area= 8,101 sf Storage= 5,032 cf

Plug-Flow detention time= 191.5 min calculated for 10,914 cf (76% of inflow)

Center-of-Mass det. time= 96.1 min (1,000.7 - 904.6)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=0.51 cfs @ 13.62 hrs HW=266.15' (Free Discharge)
↑—**1=Culvert** (Barrel Controls 0.51 cfs @ 2.70 fps)

Summary for Link DP1: Design Pt#1

Inflow Area = 538,869 sf, 9.95% Impervious, Inflow Depth > 1.21" for 25-year event
Inflow = 8.60 cfs @ 12.26 hrs, Volume= 54,209 cf
Primary = 8.60 cfs @ 12.26 hrs, Volume= 54,209 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1E: Pre-Dev

Runoff = 4.79 cfs @ 12.14 hrs, Volume= 20,126 cf, Depth> 1.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

	Area (sf)	CN	Description
	4,587	98	Roofs, HSG A
*	7,844	98	Imp, Drives/Patio, HSG A
	144,139	39	>75% Grass cover, Good, HSG A
*	8,160	98	Pond
	164,730	46	Weighted Average
	144,139		87.50% Pervious Area
	20,591		12.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	275	Total			

Summary for Subcatchment 2E: Pre Dev

Runoff = 1.69 cfs @ 12.27 hrs, Volume= 9,568 cf, Depth> 1.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

	Area (sf)	CN	Description
*	1,190	98	Paved, HSG A
	23,020	30	Woods, Good, HSG A
	58,243	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	95,575	43	Weighted Average
	94,385		98.75% Pervious Area
	1,190		1.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.1	270	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.7	370	Total			

Summary for Subcatchment 3E: Pre Dev

Runoff = 1.86 cfs @ 12.17 hrs, Volume= 7,918 cf, Depth> 1.65"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

	Area (sf)	CN	Description
*	930	98	Roofs, HSG A
	4,145	98	Paved , HSG A
	11,350	30	Woods, Good, HSG A
	33,467	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	57,732	48	Weighted Average
	52,657		91.21% Pervious Area
	5,075		8.79% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.2	240	0.0700	1.85		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
10.4	290	Total			

Summary for Subcatchment 4E: Pre Dev

Runoff = 9.00 cfs @ 12.24 hrs, Volume= 40,671 cf, Depth> 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

	Area (sf)	CN	Description
	24,014	98	Roofs, HSG A
	2,763	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
	20,740	76	Gravel roads, HSG A
*	27,786	78	Wetlands
	133,237	39	>75% Grass cover, Good, HSG A
	220,832	54	Weighted Average
	194,055		87.87% Pervious Area
	26,777		12.13% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
5.2	270	0.0150	0.86		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
2.4	210	0.0450	1.48		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.8	530	Total			

Summary for Reach 1R: Int Stream

Inflow Area = 318,037 sf, 8.44% Impervious, Inflow Depth > 1.28" for 50-year event
Inflow = 3.46 cfs @ 12.25 hrs, Volume= 33,964 cf
Outflow = 3.44 cfs @ 12.29 hrs, Volume= 33,909 cf, Atten= 1%, Lag= 2.2 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.28 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 2.41 fps, Avg. Travel Time= 1.9 min

Peak Storage= 223 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.31'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 1P: Exist Pond

Inflow Area = 164,730 sf, 12.50% Impervious, Inflow Depth > 1.47" for 50-year event
Inflow = 4.79 cfs @ 12.14 hrs, Volume= 20,126 cf
Outflow = 1.02 cfs @ 12.82 hrs, Volume= 16,479 cf, Atten= 79%, Lag= 40.5 min
Primary = 1.02 cfs @ 12.82 hrs, Volume= 16,479 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.32' @ 12.82 hrs Surf.Area= 8,232 sf Storage= 6,404 cf

Plug-Flow detention time= 152.4 min calculated for 16,444 cf (82% of inflow)

Center-of-Mass det. time= 75.5 min (967.3 - 891.8)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=1.02 cfs @ 12.82 hrs HW=266.32' (Free Discharge)
1=Culvert (Barrel Controls 1.02 cfs @ 3.13 fps)

Summary for Link DP1: Design Pt#1

Inflow Area = 538,869 sf, 9.95% Impervious, Inflow Depth > 1.66" for 50-year event
Inflow = 12.41 cfs @ 12.25 hrs, Volume= 74,579 cf
Primary = 12.41 cfs @ 12.25 hrs, Volume= 74,579 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1E: Pre-Dev

Runoff = 6.91 cfs @ 12.14 hrs, Volume= 27,053 cf, Depth> 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
	4,587	98	Roofs, HSG A
*	7,844	98	Imp, Drives/Patio, HSG A
	144,139	39	>75% Grass cover, Good, HSG A
*	8,160	98	Pond
	164,730	46	Weighted Average
	144,139		87.50% Pervious Area
	20,591		12.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.4	225	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	275	Total			

Summary for Subcatchment 2E: Pre Dev

Runoff = 2.59 cfs @ 12.25 hrs, Volume= 13,184 cf, Depth> 1.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
*	1,190	98	Paved, HSG A
	23,020	30	Woods, Good, HSG A
	58,243	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	95,575	43	Weighted Average
	94,385		98.75% Pervious Area
	1,190		1.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.1	270	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.7	370	Total			

Summary for Subcatchment 3E: Pre Dev

Runoff = 2.61 cfs @ 12.16 hrs, Volume= 10,497 cf, Depth> 2.18"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
*	930	98	Roofs, HSG A
	4,145	98	Paved , HSG A
	11,350	30	Woods, Good, HSG A
	33,467	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	57,732	48	Weighted Average
	52,657		91.21% Pervious Area
	5,075		8.79% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.2	240	0.0700	1.85		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
10.4	290	Total			

Summary for Subcatchment 4E: Pre Dev

Runoff = 11.85 cfs @ 12.24 hrs, Volume= 52,153 cf, Depth> 2.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
	24,014	98	Roofs, HSG A
	2,763	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
	20,740	76	Gravel roads, HSG A
*	27,786	78	Wetlands
	133,237	39	>75% Grass cover, Good, HSG A
	220,832	54	Weighted Average
	194,055		87.87% Pervious Area
	26,777		12.13% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
5.2	270	0.0150	0.86		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
2.4	210	0.0450	1.48		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
15.8	530	Total			

Summary for Reach 1R: Int Stream

Inflow Area = 318,037 sf, 8.44% Impervious, Inflow Depth > 1.77" for 100-year event
Inflow = 5.60 cfs @ 12.25 hrs, Volume= 46,924 cf
Outflow = 5.56 cfs @ 12.28 hrs, Volume= 46,861 cf, Atten= 1%, Lag= 1.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.95 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 2.60 fps, Avg. Travel Time= 1.8 min

Peak Storage= 312 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.40'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 1P: Exist Pond

Inflow Area = 164,730 sf, 12.50% Impervious, Inflow Depth > 1.97" for 100-year event
Inflow = 6.91 cfs @ 12.14 hrs, Volume= 27,053 cf
Outflow = 1.91 cfs @ 12.60 hrs, Volume= 23,243 cf, Atten= 72%, Lag= 27.9 min
Primary = 1.91 cfs @ 12.60 hrs, Volume= 23,243 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.55' @ 12.60 hrs Surf.Area= 8,414 sf Storage= 8,332 cf

Plug-Flow detention time= 125.9 min calculated for 23,243 cf (86% of inflow)

Center-of-Mass det. time= 62.3 min (943.6 - 881.3)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=1.91 cfs @ 12.60 hrs HW=266.55' (Free Discharge)
1=Culvert (Barrel Controls 1.91 cfs @ 3.57 fps)

Summary for Link DP1: Design Pt#1

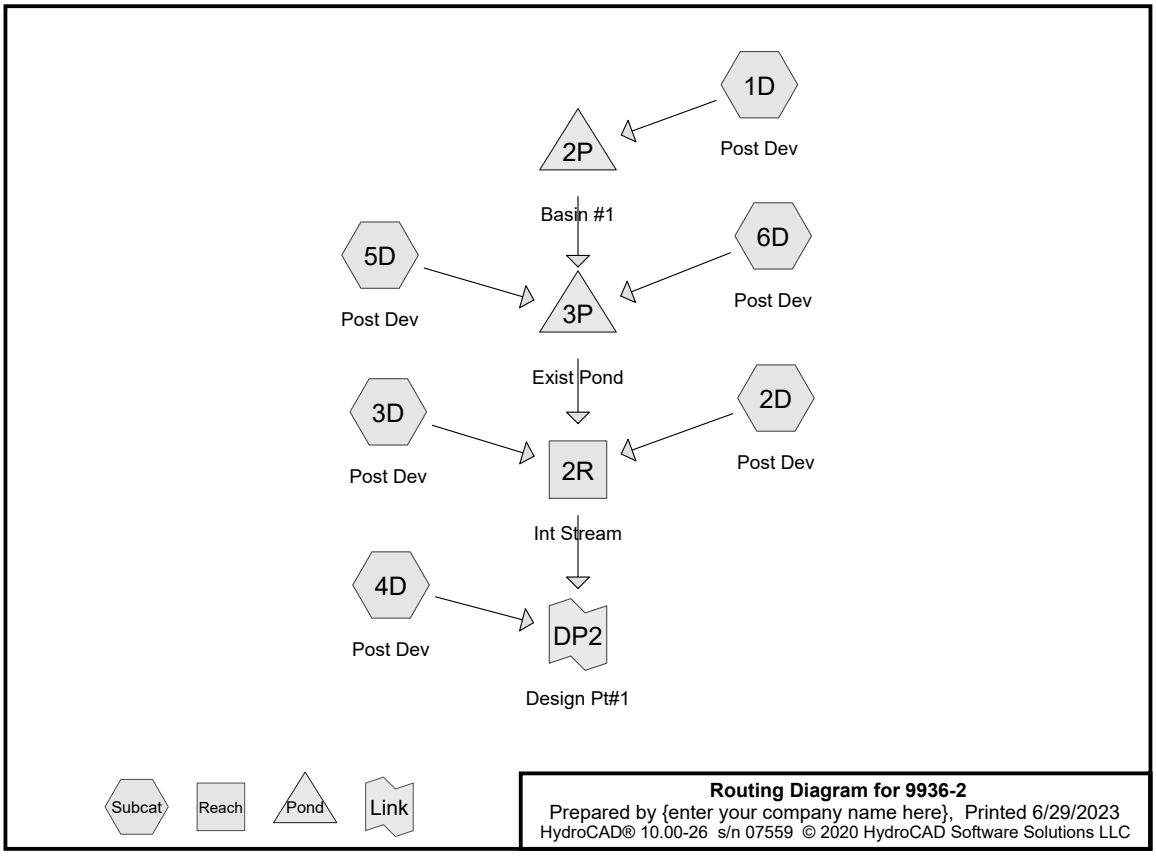
Inflow Area = 538,869 sf, 9.95% Impervious, Inflow Depth > 2.20" for 100-year event
Inflow = 17.35 cfs @ 12.25 hrs, Volume= 99,014 cf
Primary = 17.35 cfs @ 12.25 hrs, Volume= 99,014 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

APPENDIX – A2

Hydrogeological Calculations for Post-Development
HyrdoCAD

Standard 2



Summary for Subcatchment 1D: Post Dev

Runoff = 0.13 cfs @ 12.43 hrs, Volume= 1,558 cf, Depth> 0.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

Area (sf)	CN	Description
7,107	98	Roofs, HSG A
13,173	98	Paved parking, HSG A
79,857	39	>75% Grass cover, Good, HSG A
100,137	51	Weighted Average
79,857		79.75% Pervious Area
20,280		20.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.7	160	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
7.4	210	Total			

Summary for Subcatchment 2D: Post Dev

Runoff = 0.02 cfs @ 14.89 hrs, Volume= 587 cf, Depth> 0.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
*	3,034	98	Paved, HSG A
	2,510	98	Roofs, HSG A
	23,020	30	Woods, Good, HSG A
	46,996	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	88,682	46	Weighted Average
	83,138		93.75% Pervious Area
	5,544		6.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B**
					Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C**
					Unpaved Kv= 16.1 fps
4.2	275	0.0240	1.08		**Shallow Concentrated Flow, C-D**
					Short Grass Pasture Kv= 7.0 fps
14.8	375	Total			

Summary for Subcatchment 3D: Post Dev

Runoff = 0.02 cfs @ 13.83 hrs, Volume= 447 cf, Depth> 0.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
	930	98	Roofs, HSG A
	2,850	98	Paved parking, HSG A
	11,350	30	Woods, Good, HSG A
	31,709	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	54,679	47	Weighted Average
	50,899		93.09% Pervious Area
	3,780		6.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		**Sheet Flow, A-B**
					Grass: Dense n= 0.240 P2= 3.20"
1.9	220	0.0800	1.98		**Shallow Concentrated Flow, B-C**
					Short Grass Pasture Kv= 7.0 fps
8.1	270	Total			

Summary for Subcatchment 4D: Post Dev

Runoff = 0.05 cfs @ 14.85 hrs, Volume= 1,464 cf, Depth> 0.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
	5,860	98	Roofs, HSG A
	4,132	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
*	27,786	78	Wetlands
	170,742	39	>75% Grass cover, Good, HSG A
	220,812	46	Weighted Average
	210,820		95.47% Pervious Area
	9,992		4.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B**
					Grass: Dense n= 0.240 P2= 3.20"
4.7	340	0.0300	1.21		**Shallow Concentrated Flow, B-C**
					Short Grass Pasture Kv= 7.0 fps
12.9	390	Total			

Summary for Subcatchment 5D: Post Dev

Runoff = 0.17 cfs @ 12.40 hrs, Volume= 1,482 cf, Depth> 0.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

Area (sf)	CN	Description
13,422	98	Paved parking, HSG A
2,520	98	Roofs, HSG A
43,649	39	>75% Grass cover, Good, HSG A
59,591	55	Weighted Average
43,649		73.25% Pervious Area
15,942		26.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.3	190	0.0400	1.40		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.7	230	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
12.2	470	Total			

Summary for Subcatchment 6D: Post Dev

Runoff = 0.38 cfs @ 12.10 hrs, Volume= 1,282 cf, Depth> 1.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.36"

	Area (sf)	CN	Description
*	8,458	98	Pond
	6,494	39	>75% Grass cover, Good, HSG A
	14,952	72	Weighted Average
	6,494		43.43% Pervious Area
	8,458		56.57% Impervious Area

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

Summary for Reach 2R: Int Stream

Inflow Area = 318,041 sf, 16.98% Impervious, Inflow Depth > 0.04" for 2-year event
Inflow = 0.04 cfs @ 14.74 hrs, Volume= 1,147 cf
Outflow = 0.04 cfs @ 14.88 hrs, Volume= 1,130 cf, Atten= 0%, Lag= 8.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.89 fps, Min. Travel Time= 5.2 min
Avg. Velocity = 0.77 fps, Avg. Travel Time= 5.9 min

Peak Storage= 12 cf @ 14.80 hrs
Average Depth at Peak Storage= 0.02'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 2P: Basin #1

Inflow Area = 100,137 sf, 20.25% Impervious, Inflow Depth > 0.19" for 2-year event
Inflow = 0.13 cfs @ 12.43 hrs, Volume= 1,558 cf
Outflow = 0.11 cfs @ 12.53 hrs, Volume= 1,554 cf, Atten= 14%, Lag= 6.1 min
Discarded = 0.11 cfs @ 12.53 hrs, Volume= 1,554 cf
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 268.06' @ 12.53 hrs Surf.Area= 564 sf Storage= 33 cf

Plug-Flow detention time= 4.2 min calculated for 1,554 cf (100% of inflow)
Center-of-Mass det. time= 3.0 min (985.1 - 982.1)

Volume	Invert	Avail.Storage	Storage Description
#1	268.00'	8,040 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
268.00	555	90.0	0	0	555
269.00	725	104.0	638	638	792
269.10	1,254	138.0	98	736	1,447
270.00	1,530	150.0	1,251	1,987	1,751
272.00	2,180	175.0	3,691	5,677	2,474
273.00	2,550	188.0	2,363	8,040	2,892

Device	Routing	Invert	Outlet Devices
#1	Discarded	268.00'	**8.270 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 266.00'
#2	Primary	268.00'	**12.0" Round Culvert** L= 50.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 268.00' / 267.00' S= 0.0200 '/' Cc= 0.900 n= 0.013, Flow Area= 0.79 sf
#3	Device 2	270.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Device 2	271.50'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.11 cfs @ 12.53 hrs HW=268.06' (Free Discharge)
└**1=Exfiltration** (Controls 0.11 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=268.00' (Free Discharge)
└**2=Culvert** (Controls 0.00 cfs)
  ├**3=Orifice/Grate** (Controls 0.00 cfs)
  └**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 3P: Exist Pond

Inflow Area = 174,680 sf, 25.58% Impervious, Inflow Depth > 0.19" for 2-year event
Inflow = 0.41 cfs @ 12.12 hrs, Volume= 2,764 cf
Outflow = 0.01 cfs @ 24.00 hrs, Volume= 113 cf, Atten= 97%, Lag= 712.9 min
Primary = 0.01 cfs @ 24.00 hrs, Volume= 113 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 265.85' @ 24.00 hrs Surf.Area= 7,784 sf Storage= 2,650 cf

Plug-Flow detention time= 628.1 min calculated for 113 cf (4% of inflow)
Center-of-Mass det. time= 426.5 min (1,336.4 - 909.9)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=0.01 cfs @ 24.00 hrs HW=265.85' (Free Discharge)
1=Culvert (Barrel Controls 0.01 cfs @ 1.00 fps)

Summary for Link DP2: Design Pt#1

Inflow Area = 538,853 sf, 11.88% Impervious, Inflow Depth > 0.06" for 2-year event
Inflow = 0.09 cfs @ 14.86 hrs, Volume= 2,594 cf
Primary = 0.09 cfs @ 14.86 hrs, Volume= 2,594 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1D: Post Dev

Runoff = 1.53 cfs @ 12.14 hrs, Volume= 7,131 cf, Depth> 0.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

Area (sf)	CN	Description
7,107	98	Roofs, HSG A
13,173	98	Paved parking, HSG A
79,857	39	>75% Grass cover, Good, HSG A
100,137	51	Weighted Average
79,857		79.75% Pervious Area
20,280		20.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.7	160	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
7.4	210	Total			

Summary for Subcatchment 2D: Post Dev

Runoff = 0.56 cfs @ 12.39 hrs, Volume= 4,227 cf, Depth> 0.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

	Area (sf)	CN	Description
*	3,034	98	Paved, HSG A
	2,510	98	Roofs, HSG A
	23,020	30	Woods, Good, HSG A
	46,996	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	88,682	46	Weighted Average
	83,138		93.75% Pervious Area
	5,544		6.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.2	275	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.8	375	Total			

Summary for Subcatchment 3D: Post Dev

Runoff = 0.45 cfs @ 12.19 hrs, Volume= 2,856 cf, Depth> 0.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

	Area (sf)	CN	Description
	930	98	Roofs, HSG A
	2,850	98	Paved parking, HSG A
	11,350	30	Woods, Good, HSG A
	31,709	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	54,679	47	Weighted Average
	50,899		93.09% Pervious Area
	3,780		6.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.9	220	0.0800	1.98		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	270	Total			

Summary for Subcatchment 4D: Post Dev

Runoff = 1.41 cfs @ 12.35 hrs, Volume= 10,534 cf, Depth> 0.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

	Area (sf)	CN	Description
	5,860	98	Roofs, HSG A
	4,132	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
*	27,786	78	Wetlands
	170,742	39	>75% Grass cover, Good, HSG A
	220,812	46	Weighted Average
	210,820		95.47% Pervious Area
	9,992		4.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
4.7	340	0.0300	1.21		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
12.9	390	Total			

Summary for Subcatchment 5D: Post Dev

Runoff = 1.18 cfs @ 12.20 hrs, Volume= 5,479 cf, Depth> 1.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

Area (sf)	CN	Description
13,422	98	Paved parking, HSG A
2,520	98	Roofs, HSG A
43,649	39	>75% Grass cover, Good, HSG A
59,591	55	Weighted Average
43,649		73.25% Pervious Area
15,942		26.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.3	190	0.0400	1.40		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.7	230	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
12.2	470	Total			

Summary for Subcatchment 6D: Post Dev

Runoff = 0.94 cfs @ 12.10 hrs, Volume= 2,978 cf, Depth> 2.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=5.25"

Area (sf)	CN	Description
* 8,458	98	Pond
6,494	39	>75% Grass cover, Good, HSG A
14,952	72	Weighted Average
6,494		43.43% Pervious Area
8,458		56.57% Impervious Area

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

Summary for Reach 2R: Int Stream

Inflow Area = 318,041 sf, 16.98% Impervious, Inflow Depth > 0.47" for 10-year event
Inflow = 0.96 cfs @ 12.35 hrs, Volume= 12,412 cf
Outflow = 0.95 cfs @ 12.40 hrs, Volume= 12,377 cf, Atten= 0%, Lag= 2.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.81 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 1.75 fps, Avg. Travel Time= 2.6 min

Peak Storage= 93 cf @ 12.37 hrs
Average Depth at Peak Storage= 0.15'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 2P: Basin #1

Inflow Area = 100,137 sf, 20.25% Impervious, Inflow Depth > 0.85" for 10-year event
Inflow = 1.53 cfs @ 12.14 hrs, Volume= 7,131 cf
Outflow = 0.45 cfs @ 12.64 hrs, Volume= 7,119 cf, Atten= 71%, Lag= 29.7 min
Discarded = 0.45 cfs @ 12.64 hrs, Volume= 7,119 cf
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 269.67' @ 12.64 hrs Surf.Area= 1,425 sf Storage= 1,496 cf

Plug-Flow detention time= 35.5 min calculated for 7,105 cf (100% of inflow)
Center-of-Mass det. time= 34.5 min (938.9 - 904.4)

Volume	Invert	Avail.Storage	Storage Description
#1	268.00'	8,040 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
268.00	555	90.0	0	0	555
269.00	725	104.0	638	638	792
269.10	1,254	138.0	98	736	1,447
270.00	1,530	150.0	1,251	1,987	1,751
272.00	2,180	175.0	3,691	5,677	2,474
273.00	2,550	188.0	2,363	8,040	2,892

Device	Routing	Invert	Outlet Devices
#1	Discarded	268.00'	**8.270 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 266.00'
#2	Primary	268.00'	**12.0" Round Culvert** L= 50.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 268.00' / 267.00' S= 0.0200 '/' Cc= 0.900 n= 0.013, Flow Area= 0.79 sf
#3	Device 2	270.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Device 2	271.50'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.45 cfs @ 12.64 hrs HW=269.67' (Free Discharge)
└**1=Exfiltration** (Controls 0.45 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=268.00' (Free Discharge)
└**2=Culvert** (Controls 0.00 cfs)
  ├**3=Orifice/Grate** (Controls 0.00 cfs)
  └**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 3P: Exist Pond

Inflow Area = 174,680 sf, 25.58% Impervious, Inflow Depth > 0.58" for 10-year event
Inflow = 1.86 cfs @ 12.15 hrs, Volume= 8,456 cf
Outflow = 0.23 cfs @ 14.01 hrs, Volume= 5,330 cf, Atten= 88%, Lag= 111.2 min
Primary = 0.23 cfs @ 14.01 hrs, Volume= 5,330 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.03' @ 14.01 hrs Surf.Area= 8,007 sf Storage= 4,056 cf

Plug-Flow detention time= 259.3 min calculated for 5,330 cf (63% of inflow)
Center-of-Mass det. time= 140.3 min (1,013.8 - 873.5)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=0.23 cfs @ 14.01 hrs HW=266.03' (Free Discharge)
1=Culvert (Barrel Controls 0.23 cfs @ 2.26 fps)

Summary for Link DP2: Design Pt#1

Inflow Area = 538,853 sf, 11.88% Impervious, Inflow Depth > 0.51" for 10-year event
Inflow = 2.36 cfs @ 12.37 hrs, Volume= 22,911 cf
Primary = 2.36 cfs @ 12.37 hrs, Volume= 22,911 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1D: Post Dev

Runoff = 3.04 cfs @ 12.13 hrs, Volume= 11,994 cf, Depth> 1.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

Area (sf)	CN	Description
7,107	98	Roofs, HSG A
13,173	98	Paved parking, HSG A
79,857	39	>75% Grass cover, Good, HSG A
100,137	51	Weighted Average
79,857		79.75% Pervious Area
20,280		20.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.7	160	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
7.4	210	Total			

Summary for Subcatchment 2D: Post Dev

Runoff = 1.36 cfs @ 12.27 hrs, Volume= 7,746 cf, Depth> 1.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

	Area (sf)	CN	Description
*	3,034	98	Paved, HSG A
	2,510	98	Roofs, HSG A
	23,020	30	Woods, Good, HSG A
	46,996	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	88,682	46	Weighted Average
	83,138		93.75% Pervious Area
	5,544		6.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.2	275	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.8	375	Total			

Summary for Subcatchment 3D: Post Dev

Runoff = 1.13 cfs @ 12.15 hrs, Volume= 5,128 cf, Depth> 1.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

	Area (sf)	CN	Description
	930	98	Roofs, HSG A
	2,850	98	Paved parking, HSG A
	11,350	30	Woods, Good, HSG A
	31,709	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	54,679	47	Weighted Average
	50,899		93.09% Pervious Area
	3,780		6.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.9	220	0.0800	1.98		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	270	Total			

Summary for Subcatchment 4D: Post Dev

Runoff = 3.51 cfs @ 12.23 hrs, Volume= 19,301 cf, Depth> 1.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

	Area (sf)	CN	Description
	5,860	98	Roofs, HSG A
	4,132	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
*	27,786	78	Wetlands
	170,742	39	>75% Grass cover, Good, HSG A
	220,812	46	Weighted Average
	210,820		95.47% Pervious Area
	9,992		4.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
4.7	340	0.0300	1.21		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
12.9	390	Total			

Summary for Subcatchment 5D: Post Dev

Runoff = 2.07 cfs @ 12.19 hrs, Volume= 8,767 cf, Depth> 1.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

Area (sf)	CN	Description
13,422	98	Paved parking, HSG A
2,520	98	Roofs, HSG A
43,649	39	>75% Grass cover, Good, HSG A
59,591	55	Weighted Average
43,649		73.25% Pervious Area
15,942		26.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.3	190	0.0400	1.40		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.7	230	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
12.2	470	Total			

Summary for Subcatchment 6D: Post Dev

Runoff = 1.32 cfs @ 12.09 hrs, Volume= 4,168 cf, Depth> 3.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-year Rainfall=6.43"

Area (sf)	CN	Description
* 8,458	98	Pond
6,494	39	>75% Grass cover, Good, HSG A
14,952	72	Weighted Average
6,494		43.43% Pervious Area
8,458		56.57% Impervious Area

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

Summary for Reach 2R: Int Stream

Inflow Area = 318,041 sf, 16.98% Impervious, Inflow Depth > 0.89" for 25-year event
Inflow = 2.38 cfs @ 12.28 hrs, Volume= 23,713 cf
Outflow = 2.38 cfs @ 12.32 hrs, Volume= 23,672 cf, Atten= 0%, Lag= 2.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.81 fps, Min. Travel Time= 1.2 min
Avg. Velocity = 2.12 fps, Avg. Travel Time= 2.2 min

Peak Storage= 172 cf @ 12.30 hrs
Average Depth at Peak Storage= 0.25'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 2P: Basin #1

Inflow Area = 100,137 sf, 20.25% Impervious, Inflow Depth > 1.44" for 25-year event
Inflow = 3.04 cfs @ 12.13 hrs, Volume= 11,994 cf
Outflow = 1.26 cfs @ 12.49 hrs, Volume= 11,976 cf, Atten= 58%, Lag= 21.6 min
Discarded = 0.61 cfs @ 12.49 hrs, Volume= 10,805 cf
Primary = 0.65 cfs @ 12.49 hrs, Volume= 1,171 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 270.49' @ 12.49 hrs Surf.Area= 1,678 sf Storage= 2,770 cf

Plug-Flow detention time= 42.9 min calculated for 11,951 cf (100% of inflow)
Center-of-Mass det. time= 42.0 min (926.7 - 884.7)

Volume	Invert	Avail.Storage	Storage Description
#1	268.00'	8,040 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
268.00	555	90.0	0	0	555
269.00	725	104.0	638	638	792
269.10	1,254	138.0	98	736	1,447
270.00	1,530	150.0	1,251	1,987	1,751
272.00	2,180	175.0	3,691	5,677	2,474
273.00	2,550	188.0	2,363	8,040	2,892

Device	Routing	Invert	Outlet Devices
#1	Discarded	268.00'	**8.270 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 266.00'
#2	Primary	268.00'	**12.0" Round Culvert** L= 50.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 268.00' / 267.00' S= 0.0200 '/' Cc= 0.900 n= 0.013, Flow Area= 0.79 sf
#3	Device 2	270.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Device 2	271.50'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.61 cfs @ 12.49 hrs HW=270.49' (Free Discharge)
└**1=Exfiltration** (Controls 0.61 cfs)

Primary OutFlow Max=0.65 cfs @ 12.49 hrs HW=270.49' (Free Discharge)
└**2=Culvert** (Passes 0.65 cfs of 5.33 cfs potential flow)
  ├**3=Orifice/Grate** (Orifice Controls 0.65 cfs @ 2.37 fps)
  └**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 3P: Exist Pond

Inflow Area = 174,680 sf, 25.58% Impervious, Inflow Depth > 0.97" for 25-year event
Inflow = 3.06 cfs @ 12.15 hrs, Volume= 14,107 cf
Outflow = 0.87 cfs @ 12.83 hrs, Volume= 10,839 cf, Atten= 72%, Lag= 41.0 min
Primary = 0.87 cfs @ 12.83 hrs, Volume= 10,839 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.27' @ 12.83 hrs Surf.Area= 8,196 sf Storage= 6,032 cf

Plug-Flow detention time= 178.1 min calculated for 10,839 cf (77% of inflow)
Center-of-Mass det. time= 92.1 min (944.5 - 852.4)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=0.87 cfs @ 12.83 hrs HW=266.27' (Free Discharge)
1=Culvert (Barrel Controls 0.87 cfs @ 3.02 fps)

Summary for Link DP2: Design Pt#1

Inflow Area = 538,853 sf, 11.88% Impervious, Inflow Depth > 0.96" for 25-year event
Inflow = 5.83 cfs @ 12.26 hrs, Volume= 42,973 cf
Primary = 5.83 cfs @ 12.26 hrs, Volume= 42,973 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1D: Post Dev

Runoff = 4.39 cfs @ 12.12 hrs, Volume= 16,080 cf, Depth> 1.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

Area (sf)	CN	Description
7,107	98	Roofs, HSG A
13,173	98	Paved parking, HSG A
79,857	39	>75% Grass cover, Good, HSG A
100,137	51	Weighted Average
79,857		79.75% Pervious Area
20,280		20.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.7	160	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
7.4	210	Total			

Summary for Subcatchment 2D: Post Dev

Runoff = 2.12 cfs @ 12.25 hrs, Volume= 10,810 cf, Depth> 1.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

	Area (sf)	CN	Description
*	3,034	98	Paved, HSG A
	2,510	98	Roofs, HSG A
	23,020	30	Woods, Good, HSG A
	46,996	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	88,682	46	Weighted Average
	83,138		93.75% Pervious Area
	5,544		6.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.2	275	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.8	375	Total			

Summary for Subcatchment 3D: Post Dev

Runoff = 1.73 cfs @ 12.14 hrs, Volume= 7,090 cf, Depth> 1.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

	Area (sf)	CN	Description
	930	98	Roofs, HSG A
	2,850	98	Paved parking, HSG A
	11,350	30	Woods, Good, HSG A
	31,709	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	54,679	47	Weighted Average
	50,899		93.09% Pervious Area
	3,780		6.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.9	220	0.0800	1.98		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	270	Total			

Summary for Subcatchment 4D: Post Dev

Runoff = 5.57 cfs @ 12.22 hrs, Volume= 26,934 cf, Depth> 1.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

	Area (sf)	CN	Description
	5,860	98	Roofs, HSG A
	4,132	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
*	27,786	78	Wetlands
	170,742	39	>75% Grass cover, Good, HSG A
	220,812	46	Weighted Average
	210,820		95.47% Pervious Area
	9,992		4.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
4.7	340	0.0300	1.21		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
12.9	390	Total			

Summary for Subcatchment 5D: Post Dev

Runoff = 2.81 cfs @ 12.19 hrs, Volume= 11,472 cf, Depth> 2.31"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

Area (sf)	CN	Description
13,422	98	Paved parking, HSG A
2,520	98	Roofs, HSG A
43,649	39	>75% Grass cover, Good, HSG A
59,591	55	Weighted Average
43,649		73.25% Pervious Area
15,942		26.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.3	190	0.0400	1.40		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.7	230	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
12.2	470	Total			

Summary for Subcatchment 6D: Post Dev

Runoff = 1.61 cfs @ 12.09 hrs, Volume= 5,087 cf, Depth> 4.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 50-year Rainfall=7.30"

Area (sf)	CN	Description
* 8,458	98	Pond
6,494	39	>75% Grass cover, Good, HSG A
14,952	72	Weighted Average
6,494		43.43% Pervious Area
8,458		56.57% Impervious Area

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

Summary for Reach 2R: Int Stream

Inflow Area = 318,041 sf, 16.98% Impervious, Inflow Depth > 1.29" for 50-year event
Inflow = 3.95 cfs @ 12.29 hrs, Volume= 34,258 cf
Outflow = 3.95 cfs @ 12.32 hrs, Volume= 34,211 cf, Atten= 0%, Lag= 1.8 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.46 fps, Min. Travel Time= 1.0 min
Avg. Velocity = 2.34 fps, Avg. Travel Time= 2.0 min

Peak Storage= 244 cf @ 12.31 hrs
Average Depth at Peak Storage= 0.33'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 2P: Basin #1

Inflow Area = 100,137 sf, 20.25% Impervious, Inflow Depth > 1.93" for 50-year event
Inflow = 4.39 cfs @ 12.12 hrs, Volume= 16,080 cf
Outflow = 1.97 cfs @ 12.43 hrs, Volume= 16,058 cf, Atten= 55%, Lag= 18.4 min
Discarded = 0.70 cfs @ 12.43 hrs, Volume= 12,893 cf
Primary = 1.28 cfs @ 12.43 hrs, Volume= 3,166 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 270.91' @ 12.43 hrs Surf.Area= 1,812 sf Storage= 3,505 cf

Plug-Flow detention time= 42.0 min calculated for 16,025 cf (100% of inflow)
Center-of-Mass det. time= 41.2 min (915.9 - 874.8)

Volume	Invert	Avail.Storage	Storage Description
#1	268.00'	8,040 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
268.00	555	90.0	0	0	555
269.00	725	104.0	638	638	792
269.10	1,254	138.0	98	736	1,447
270.00	1,530	150.0	1,251	1,987	1,751
272.00	2,180	175.0	3,691	5,677	2,474
273.00	2,550	188.0	2,363	8,040	2,892

Device	Routing	Invert	Outlet Devices
#1	Discarded	268.00'	**8.270 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 266.00'
#2	Primary	268.00'	**12.0" Round Culvert** L= 50.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 268.00' / 267.00' S= 0.0200 '/' Cc= 0.900 n= 0.013, Flow Area= 0.79 sf
#3	Device 2	270.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Device 2	271.50'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.70 cfs @ 12.43 hrs HW=270.91' (Free Discharge)
└**1=Exfiltration** (Controls 0.70 cfs)

Primary OutFlow Max=1.27 cfs @ 12.43 hrs HW=270.91' (Free Discharge)
└**2=Culvert** (Passes 1.27 cfs of 5.87 cfs potential flow)
  ├**3=Orifice/Grate** (Orifice Controls 1.27 cfs @ 3.65 fps)
  └**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 3P: Exist Pond

Inflow Area = 174,680 sf, 25.58% Impervious, Inflow Depth > 1.35" for 50-year event
Inflow = 4.55 cfs @ 12.21 hrs, Volume= 19,724 cf
Outflow = 1.75 cfs @ 12.72 hrs, Volume= 16,358 cf, Atten= 62%, Lag= 30.8 min
Primary = 1.75 cfs @ 12.72 hrs, Volume= 16,358 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.51' @ 12.72 hrs Surf.Area= 8,383 sf Storage= 8,002 cf

Plug-Flow detention time= 140.7 min calculated for 16,324 cf (83% of inflow)
Center-of-Mass det. time= 73.0 min (911.5 - 838.5)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=1.74 cfs @ 12.72 hrs HW=266.51' (Free Discharge)
1=Culvert (Barrel Controls 1.74 cfs @ 3.50 fps)

Summary for Link DP2: Design Pt#1

Inflow Area = 538,853 sf, 11.88% Impervious, Inflow Depth > 1.36" for 50-year event
Inflow = 9.28 cfs @ 12.24 hrs, Volume= 61,145 cf
Primary = 9.28 cfs @ 12.24 hrs, Volume= 61,145 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Subcatchment 1D: Post Dev

Runoff = 5.94 cfs @ 12.12 hrs, Volume= 20,937 cf, Depth> 2.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

Area (sf)	CN	Description
7,107	98	Roofs, HSG A
13,173	98	Paved parking, HSG A
79,857	39	>75% Grass cover, Good, HSG A
100,137	51	Weighted Average
79,857		79.75% Pervious Area
20,280		20.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.7	50	0.0500	0.15		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.7	160	0.0500	1.57		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
7.4	210	Total			

Summary for Subcatchment 2D: Post Dev

Runoff = 3.06 cfs @ 12.24 hrs, Volume= 14,533 cf, Depth> 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
*	3,034	98	Paved, HSG A
	2,510	98	Roofs, HSG A
	23,020	30	Woods, Good, HSG A
	46,996	39	>75% Grass cover, Good, HSG A
*	13,122	78	Wetlands/wooded
	88,682	46	Weighted Average
	83,138		93.75% Pervious Area
	5,544		6.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.5	50	0.0300	0.08		**Sheet Flow, A-B** Woods: Light underbrush n= 0.400 P2= 3.20"
0.1	50	0.1300	5.80		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
4.2	275	0.0240	1.08		**Shallow Concentrated Flow, C-D** Short Grass Pasture Kv= 7.0 fps
14.8	375	Total			

Summary for Subcatchment 3D: Post Dev

Runoff = 2.46 cfs @ 12.13 hrs, Volume= 9,462 cf, Depth> 2.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
	930	98	Roofs, HSG A
	2,850	98	Paved parking, HSG A
	11,350	30	Woods, Good, HSG A
	31,709	39	>75% Grass cover, Good, HSG A
*	7,840	78	Wetlands
	54,679	47	Weighted Average
	50,899		93.09% Pervious Area
	3,780		6.91% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
1.9	220	0.0800	1.98		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
8.1	270	Total			

Summary for Subcatchment 4D: Post Dev

Runoff = 8.05 cfs @ 12.21 hrs, Volume= 36,209 cf, Depth> 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
	5,860	98	Roofs, HSG A
	4,132	98	Paved parking, HSG A
	12,292	30	Woods, Good, HSG A
*	27,786	78	Wetlands
	170,742	39	>75% Grass cover, Good, HSG A
	220,812	46	Weighted Average
	210,820		95.47% Pervious Area
	9,992		4.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
4.7	340	0.0300	1.21		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
12.9	390	Total			

Summary for Subcatchment 5D: Post Dev

Runoff = 3.67 cfs @ 12.18 hrs, Volume= 14,641 cf, Depth> 2.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

Area (sf)	CN	Description
13,422	98	Paved parking, HSG A
2,520	98	Roofs, HSG A
43,649	39	>75% Grass cover, Good, HSG A
59,591	55	Weighted Average
43,649		73.25% Pervious Area
15,942		26.75% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow, A-B** Grass: Dense n= 0.240 P2= 3.20"
2.3	190	0.0400	1.40		**Shallow Concentrated Flow, B-C** Short Grass Pasture Kv= 7.0 fps
1.7	230	0.0200	2.28		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
12.2	470	Total			

Summary for Subcatchment 6D: Post Dev

Runoff = 1.94 cfs @ 12.09 hrs, Volume= 6,118 cf, Depth> 4.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

Area (sf)	CN	Description
* 8,458	98	Pond
6,494	39	>75% Grass cover, Good, HSG A
14,952	72	Weighted Average
6,494		43.43% Pervious Area
8,458		56.57% Impervious Area

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

Summary for Reach 2R: Int Stream

Inflow Area = 318,041 sf, 16.98% Impervious, Inflow Depth > 1.78" for 100-year event
Inflow = 6.06 cfs @ 12.27 hrs, Volume= 47,064 cf
Outflow = 6.04 cfs @ 12.30 hrs, Volume= 47,012 cf, Atten= 0%, Lag= 2.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.06 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 2.52 fps, Avg. Travel Time= 1.8 min

Peak Storage= 329 cf @ 12.28 hrs
Average Depth at Peak Storage= 0.42'
Bank-Full Depth= 1.50' Flow Area= 7.5 sf, Capacity= 75.40 cfs

2.00' x 1.50' deep channel, n= 0.025 Earth, grassed & winding
Side Slope Z-value= 2.0 '/' Top Width= 8.00'
Length= 275.0' Slope= 0.0349 '/'
Inlet Invert= 265.60', Outlet Invert= 256.00'

Summary for Pond 2P: Basin #1

Inflow Area = 100,137 sf, 20.25% Impervious, Inflow Depth > 2.51" for 100-year event
Inflow = 5.94 cfs @ 12.12 hrs, Volume= 20,937 cf
Outflow = 2.63 cfs @ 12.41 hrs, Volume= 20,820 cf, Atten= 56%, Lag= 17.7 min
Discarded = 0.82 cfs @ 12.41 hrs, Volume= 15,046 cf
Primary = 1.81 cfs @ 12.41 hrs, Volume= 5,774 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 271.49' @ 12.41 hrs Surf.Area= 2,004 sf Storage= 4,618 cf

Plug-Flow detention time= 41.6 min calculated for 20,777 cf (99% of inflow)
Center-of-Mass det. time= 38.4 min (904.6 - 866.3)

Volume	Invert	Avail.Storage	Storage Description
#1	268.00'	8,040 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
268.00	555	90.0	0	0	555
269.00	725	104.0	638	638	792
269.10	1,254	138.0	98	736	1,447
270.00	1,530	150.0	1,251	1,987	1,751
272.00	2,180	175.0	3,691	5,677	2,474
273.00	2,550	188.0	2,363	8,040	2,892

Device	Routing	Invert	Outlet Devices
#1	Discarded	268.00'	**8.270 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 266.00'
#2	Primary	268.00'	**12.0" Round Culvert** L= 50.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 268.00' / 267.00' S= 0.0200 '/' Cc= 0.900 n= 0.013, Flow Area= 0.79 sf
#3	Device 2	270.00'	**8.0" Vert. Orifice/Grate** C= 0.600
#4	Device 2	271.50'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.82 cfs @ 12.41 hrs HW=271.49' (Free Discharge)
└**1=Exfiltration** (Controls 0.82 cfs)

Primary OutFlow Max=1.81 cfs @ 12.41 hrs HW=271.49' (Free Discharge)
└**2=Culvert** (Passes 1.81 cfs of 6.54 cfs potential flow)
  ├**3=Orifice/Grate** (Orifice Controls 1.81 cfs @ 5.18 fps)
  └**4=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 3P: Exist Pond

Inflow Area = 174,680 sf, 25.58% Impervious, Inflow Depth > 1.82" for 100-year event
Inflow = 6.46 cfs @ 12.17 hrs, Volume= 26,533 cf
Outflow = 2.74 cfs @ 12.67 hrs, Volume= 23,068 cf, Atten= 57%, Lag= 30.0 min
Primary = 2.74 cfs @ 12.67 hrs, Volume= 23,068 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 266.74' @ 12.67 hrs Surf.Area= 8,563 sf Storage= 9,932 cf

Plug-Flow detention time= 116.7 min calculated for 23,020 cf (87% of inflow)
Center-of-Mass det. time= 61.8 min (890.7 - 829.0)

Volume	Invert	Avail.Storage	Storage Description
#1	265.50'	31,918 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
265.50	7,320	323.0	0	0	7,320
266.00	7,985	337.0	3,825	3,825	8,074
268.00	9,598	369.0	17,558	21,383	10,005
269.00	11,500	394.0	10,535	31,918	11,570

Device	Routing	Invert	Outlet Devices
#1	Primary	265.80'	**15.0" Round Culvert** L= 18.0' Ke= 0.500 Inlet / Outlet Invert= 265.80' / 265.60' S= 0.0111 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf

Primary OutFlow Max=2.74 cfs @ 12.67 hrs HW=266.74' (Free Discharge)
1=Culvert (Barrel Controls 2.74 cfs @ 3.86 fps)

Summary for Link DP2: Design Pt#1

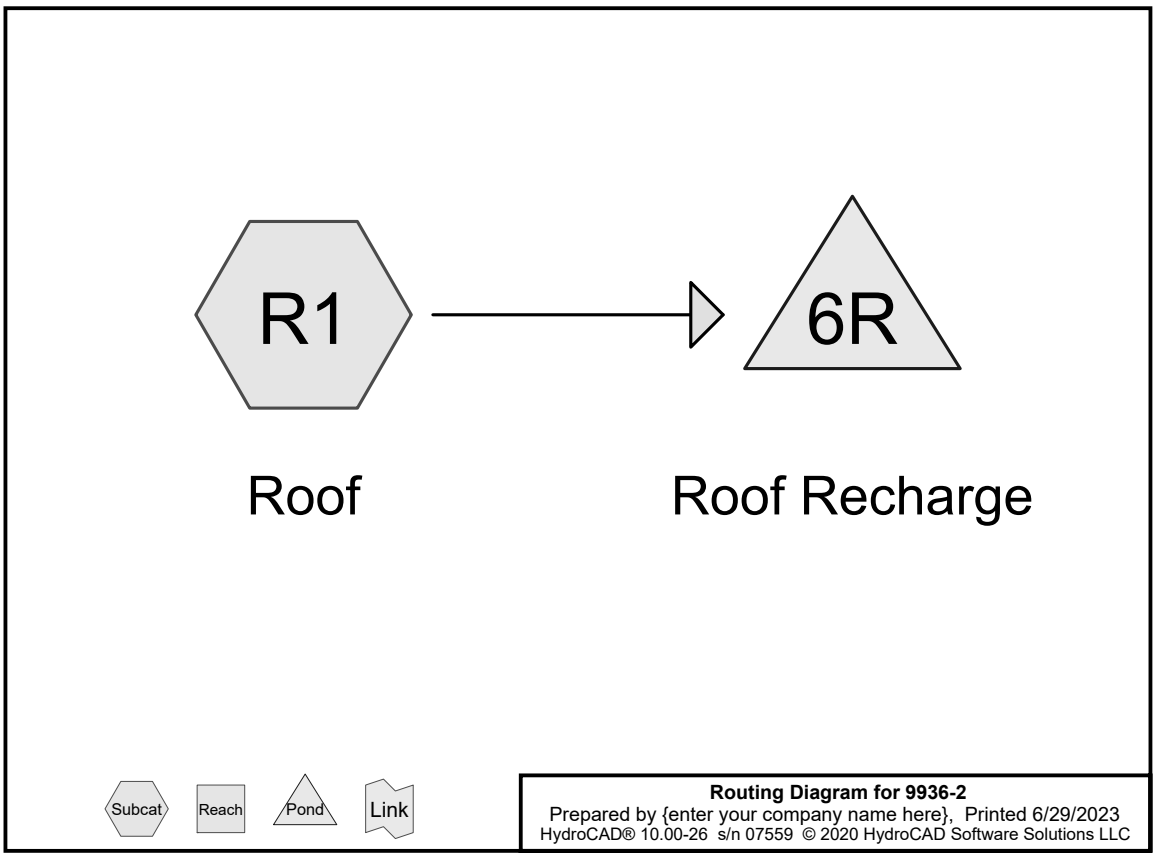
Inflow Area = 538,853 sf, 11.88% Impervious, Inflow Depth > 1.85" for 100-year event
Inflow = 13.89 cfs @ 12.22 hrs, Volume= 83,221 cf
Primary = 13.89 cfs @ 12.22 hrs, Volume= 83,221 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

APPENDIX – A3

Hydrogeological Calculations for Roof Area
HyrdoCAD

Standard 2



Summary for Subcatchment R1: Roof

Runoff = 0.23 cfs @ 12.09 hrs, Volume= 837 cf, Depth> 8.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=8.25"

	Area (sf)	CN	Description
*	1,255	98	Roof
	1,255		100.00% Impervious Area

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

Summary for Pond 6R: Roof Recharge

Inflow Area = 1,255 sf,100.00% Impervious, Inflow Depth > 8.01" for 100-year event
Inflow = 0.23 cfs @ 12.09 hrs, Volume= 837 cf
Outflow = 0.09 cfs @ 12.32 hrs, Volume= 837 cf, Atten= 61%, Lag= 13.9 min
Discarded = 0.09 cfs @ 12.32 hrs, Volume= 837 cf

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 271.07' @ 12.32 hrs Surf.Area= 104 sf Storage= 166 cf

Plug-Flow detention time= 13.9 min calculated for 835 cf (100% of inflow)
Center-of-Mass det. time= 13.8 min (754.2 - 740.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	268.00'	122 cf	**8.33'W x 12.50'L x 3.54'H Field A** 369 cf Overall - 63 cf Embedded = 306 cf x 40.0% Voids
#2A	268.50'	63 cf	**Cultec R-330XLHD** Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 1 rows
		186 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	268.00'	**8.270 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 266.00'

Discarded OutFlow Max=0.09 cfs @ 12.32 hrs HW=271.06' (Free Discharge)
↑**1=Exfiltration** (Controls 0.09 cfs)

APPENDIX – B

Hydraulic Design (Manning's Equation)
Time of Flow, Average CN values

STORM DRAINAGE CALCULATIONS

Pipe Flow Calculations - Manning's Equation

i = Rainfall Intensity at 25 Year Storm

Date: 3/2/23
Revised:
Job No: 9,936
Calc. by: rst

Project: **Beaver Brook Farm**
Town: **Holliston, MA**

Line		Length	Drain Area	Total Area	Runoff	Time of Concentration (min.)			Rainfall i	Required Capacity Q(cfs)		Pipe Diameter	Slope	Design Conditions		Invert Elevation		Rim Elev.	
From	To	(Feet)	(Ac)	(Ac)	"C"	Upper End	In Pipe	Total	(in./hr.)	Inlet	Pipe	(in.)	(ft./ft.)	Depth (in.)	Velocity (f.p.s.)	Upper	Lower	Upper	n
CB 1	DMH 3	9	0.23		0.46	10.83	0.04	10.87	5.04	0.53		12	0.022	4.40	3.70	270.20	270.00	273.76	0.013
CB 2	DMH 3	4	0.67		0.45	17.10	0.01	17.11	4.22	1.28		12	0.050	2.30	7.10	270.20	270.00	273.76	0.013
DMH 3	OUTLET 4	24		0.90	0.45	17.11	0.08	17.19	4.22		1.72	12	0.037	8.60	5.10	269.90	269.00	273.68	0.013
CB 5	DMH 7	18	0.06		0.73	6.50	0.08	6.57	5.95	0.25		12	0.011	2.40	3.90	269.50	269.30	272.60	0.013
CB 6	DMH 7	10	0.67		0.44	21.60	0.04	21.64	3.81	1.13		12	0.020	2.40	3.90	269.50	269.30	272.60	0.013
DMH 7	OUTLET 8	25		0.73	0.46	21.64	0.09	21.73	3.80		1.29	12	0.008	9.60	4.60	269.20	269.00	272.90	
CB 9	DMH 11	27	1.22		0.44	10.92	0.09	11.01	5.02	2.70		12	0.007	4.30	5.20	267.80	267.60	270.87	0.013
CB 10	DMH 11	25	0.12		0.75	12.97	0.08	13.05	4.72	0.44		12	0.008	4.30	5.20	267.80	267.60	270.87	0.013
DMH 11	OUTLET 12	30		1.34	0.47	13.05	0.11	13.17	4.71		2.97	12	0.010	5.60	4.40	267.30	267.00	271.13	0.013

OVERLAND FLOW TRAVEL TIME

STORM RUNOFF DATA

Date: **3/2/23**
Revised:

Project: **Beaver Brook Farm**
Town: **Holliston, MA**

Job No: **9,936**
Calc. by: **rst**

Structure	Impervious			Lawn			Wooded			Total
	Length (ft)	Slope ('/')	Time (min.)	Length (ft)	Slope ('/')	Time (min.)	Length (ft)	Slope ('/')	Time (min.)	Travel Time (min.)
1	**150**	**0.020**	**1.67**	**30**	**0.020**	**9.16**				10.83
2	**150**	**0.020**	**1.67**	**130**	**0.040**	**15.43**				17.10
5	**150**	**0.010**	**2.18**	**6**	**0.020**	**4.32**				6.50
6	**160**	**0.010**	**2.29**	**210**	**0.040**	**19.31**				21.60
9	**260**	**0.010**	**3.32**	**10**	**0.005**	**7.59**				10.92
10	**140**	**0.015**	**1.77**	**40**	**0.015**	**11.21**				12.97

Energy Dissipators

STORM RUNOFF DATA

Date: **6/28/23**
Revised:

Project: **Beaver Brook Farm**
Town: **Holliston, MA**

Job No: **9,936**
Calc. by: **rst**

$$D_{50} = 0.2D[Q/(g)^{1/2}D^{2.5}]^{4/3}[D/Tw]$$

D = Diameter, ft.
g = accel. Of gravity, 32.2 f.p.s.
Q = Discharge rate, c.f.s.
D50 = Riprap size, ft.(minimum)
Tw = Tailwater Depth, ft.(Unknown Tw = 0.4 x D)

Class	D_{50}(in.)	Apron Length	Apron Depth
1	5	4D	$3.5D_{50}$
2	6	4D	$3.3D_{50}$
3	10	5D	$2.4D_{50}$

Width(at apron end) = 3D+(2/3)L

Note: Formulas taken from HEC No. 14; Publication No. FHWA-NHI-06-086 July 2006

(1) **Outlet #12 & Det. Basin**

D =	1.00	ft.
Q =	2.97	c.f.s.
Tw =	0.40	ft.
D_{50} =	0.21	ft.
=	2.54	inches
RipRap Class =	1	
L=	4.00	ft. (min.)
Depth =	8.88	inches (min.)
W =	5.67	ft. (min)

AVERAGE 'c' VALUE FOR STRUCTURES

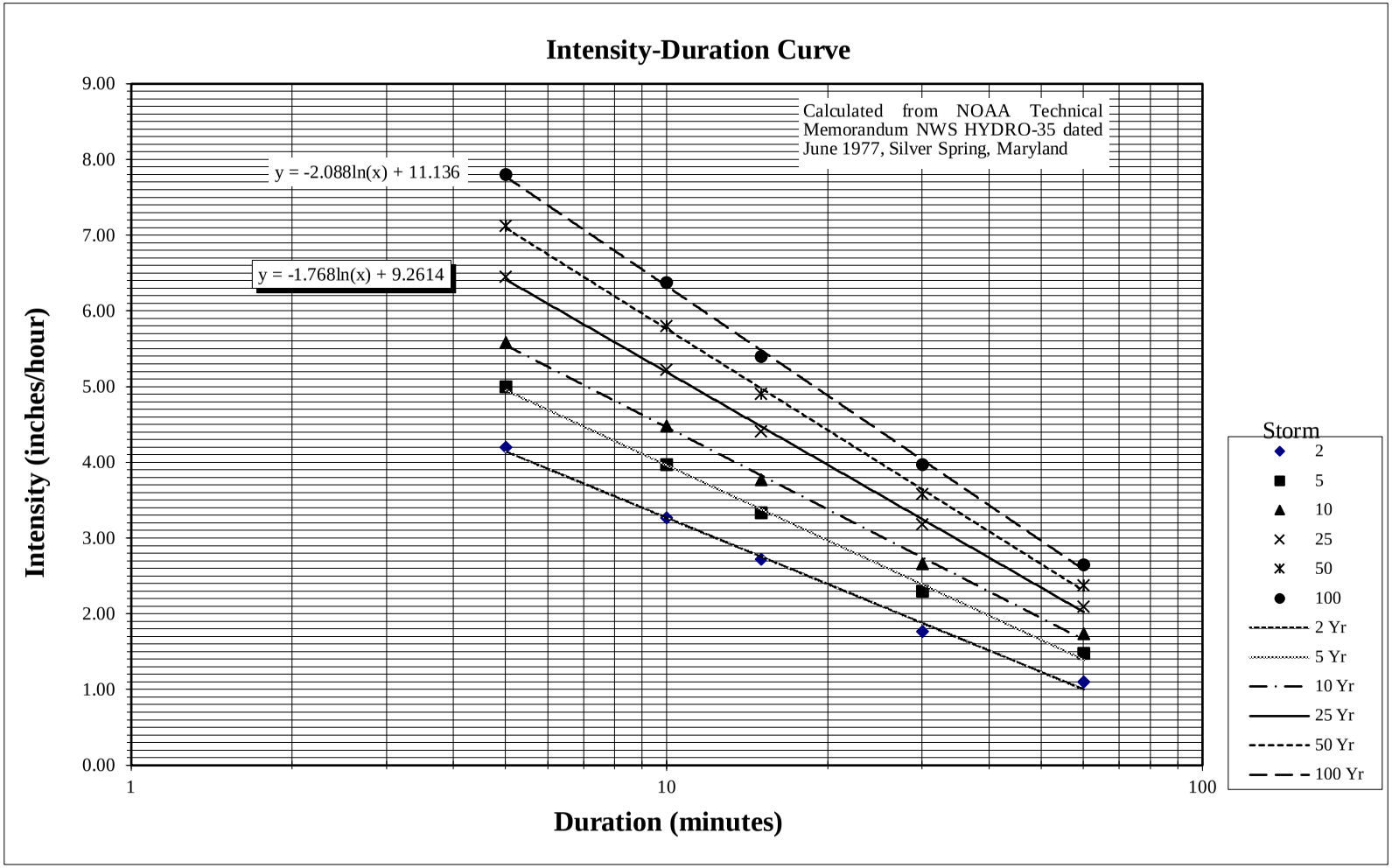
STORM RUNOFF DATA

Date: **3/2/23**
Revised:

Project: **Beaver Brook Farm**
Town: **Holliston, MA**

Job No: **9,936**
Calc. by: **RST**

Structure	Total Area (SF)	Ground Cover	Area (SF)	c	Σ(Area*c)	Average c	Total Area (Ac)
CB#1	9,812	imp	2,477	0.95	2,353.15	0.46	0.225
		lawn	7,335	0.30	2,200.50		
		wooded	0	0.20	0.00		
CB#2	29,182	imp	6,782	0.95	6,442.90	0.45	0.670
		lawn	22,400	0.30	6,720.00		
		wooded	0	0.20	0.00		
CB#5	2,476	imp	1,654	0.95	1,571.30	0.73	0.057
		lawn	822	0.30	246.60		
		wooded	0	0.20	0.00		
CB#6	29,347	imp	6,385	0.95	6,065.75	0.44	0.674
		lawn	22,962	0.30	6,888.60		
		wooded	0	0.20	0.00		
CB#9	53084	imp	11546	0.95	10968.7	0.44	1.22
		lawn	41538	0.3	12461.4		
		wooded	0	0.2	0		
CB#10	5423	imp	3732	0.95	3545.4	0.75	0.12
		lawn	1691	0.3	507.3		
		wooded	0	0.2	0		


Intensity-Duration Curve
Calculated from NOAA Technical Memorandum NWS HYDRO-35 dated June 1977, Silver Spring, Maryland
y = -2.088ln(x) + 11.136
y = -1.768ln(x) + 9.2614
Intensity (inches/hour)
Duration (minutes)
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
1
10
100
Storm
2
5
10
25
50
100
2 Yr
5 Yr
10 Yr
25 Yr
50 Yr
100 Yr

APPENDIX – C

Stormwater Recharge Calculations, Water Quality Volumes, TSS Removal & Infiltration BMP Drain Time
Groundwater Mounding Calculations

Standards 3 & 4:

APPENDIX – B
Stormwater Recharge, Water Quality & Forebay Calculations
Standard 3 & 4:

Project:
Beaver Brook Farm
Holliston, Massachusetts
Date: March 7, 2023

Water Quality Volume (WQV): Based on 1.0 inch rainfall
Recharge Volume(Rv): Based on Soil Classification
Soil Classification: "A" F = 0.60 inch
Infiltration K = 8.27 in/hr (Rawles Table)

Rv = F * Impervious Area
Rv = Required Recharge Volume
F = Depth Factor
Soil Type A – 0.60 inch
Soil Type B – 0.35 inch
Soil Type C – 0.25 inch
Soil Type D – 0.00 inch

Existing Impervious Area:

Roadway/Drives:	15,942 s.f.
Roof Area:	29,531 s.f.
Total Imp. Area:	45,473 s.f.

*Note: Existing Barn & Accessory structures to be razed.
Two existing homes to remain(Lot 1 & Lot 6)
Proposed 5 New homes (2,520 s.f./house)

Proposed/Post Impervious Area:

Roadway/Drives:	36,550 s.f.
Roof Area:	15,597 s.f.
Total Imp. Area:	52,147 s.f.

Total Impervious to Roof Area to Recharge:	12,600 s.f.
Total Impervious to Recharge Basin:	17,627 s.f.

Recharge Volume Roof Areas (New dwellings):
Recharge Volume Required: (Soil Type A – 0.60 inch)
Each system captures 50% of the roof area.
Roof Area: (Largest house) 2,520 s.f
Rv = (0.6 inch * 1260 s.f.)/ 12 = 63 c.f.

Recharge Volume Provided:
Cultec Unit R-330XLHD w/stone:
Volume system (2 per hse): 185 c.f.
Total Volume per dwelling: 2 x 185 = 370 c.f.

Time to drain:
Drawdown time = Volume/(K*Bottom Area)
Volume = 21 cf
K=8.27 in/hr = 0.69 ft/hr
Bottom Area = 104 sf
Drawdown time = 185/(0.69 ft/hr x 104 sf)
Drawdown time = 2.6 hr < 72 hr ***ok***

Drainage Basin #1 :
Imp. Area Pavement: 12,589 s.f.
New Roof to Recharge: 2,520 s.f.
Exist Roof area to basin: 5,038 s.f

WQV = (12,589 sf * 1.0 in)/12 = 1049 c.f.

Recharge Volume Required: (Soil Type A – 0.60 inch)
Imp Area: (Pavement + Exist Roof) 17,627 s.f.
Rv = (17,627 sf * 0.60 in)/12 = 881 c.f.

Storage Volume below outlet
"Static" Storage Volume Provided:
Volume (Outlet 270.0) provided = 1,987 c.f.
1,987 > 1,049 c.f. **OK**

Forebay Sizing:
Forebay Volume Required: (Paved Area) x 0.10 inch of runoff
(12,589 s.f. x 0.10 in)/12 = 105 cu.ft.
Forebay Volume Provided:

Elev. (ft.)	Area (s.f.)	Inc.Store (cu.ft.)	Cum.Store (cu.ft.)
268.0	327	0	0
281.0	458	392	392

Total Storage Povided: 392 c.f.
392 cf > 105 cf ***ok***

Time to basin to drain (WQV):
Drawdown time = Volume/(K*Bottom Area)
Volume = 1049 cf
K=8.27 in/hr = 0.69 ft/hr
Bottom Area = 555 sf
Drawdown time = 1049/(0.69 ft/hr x 555 sf)
Drawdown time = 2.73 hr < 72 hr ***ok***

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Pretreatment Outlet #4

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**0.25**	**1.00**	**0.25**	**0.75**
Sediment Forebay	**0.25**	**0.75**	**0.19**	**0.56**
	0.00	**0.56**	**0.00**	**0.56**
	0.00	**0.56**	**0.00**	**0.56**
	0.00	**0.56**	**0.00**	**0.56**

Total TSS Removal = **44%**

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

Project: Beaver Brook Farm
Prepared By: GLM
Date: 6/27/2023

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

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

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Pretreatment Outlet #8

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	0.25	1.00	0.25	0.75
Sediment Forebay	0.25	0.75	0.19	0.56
	0.00	0.56	0.00	0.56
	0.00	0.56	0.00	0.56
	0.00	0.56	0.00	0.56

Total TSS Removal = 44%

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

Project: Beaver Brook Farm
Prepared By: GLM
Date: 6/27/2023

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

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

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: Retention Basin Treatment w/44% Pretreatment

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Infiltration Basin	**0.80**	**1.00**	**0.80**	**0.20**
	0.00	**0.20**	**0.00**	**0.20**
	0.00	**0.20**	**0.00**	**0.20**
	0.00	**0.20**	**0.00**	**0.20**
	0.00	**0.20**	**0.00**	**0.20**

Total TSS Removal = **80%**

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

Project: Beaver Brook Farm
Prepared By: GLM
Date: 6/27/2023

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

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

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

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

Location: OUTLET #12

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
DEEP SUMP CATCH BASIN	.25	1.00	.25	.75
PROPRIETARY CDS UNIT	.80	0.75	.60	0.15

Total TSS Removal = 85 %

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

Project: BEAVER BROOK

Prepared By: GLM

Date: 3/2/2023

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

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1

Estimated Net Annual Solids Load Reduction
Based on the Rational Rainfall Method

CONTECH ENGINEERED SOLUTIONS

CASCADE separator™

Beaver Brook Farm
WQS

AREA	1.34	acres	**CASCADE MODEL**	CS-4
WEIGHTED C	0.47			
TC	6.00	minutes	**RAINFALL STATION**	68

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Hydraulic Loading Rate (gpm/ft2)	Removal Efficiency (%)	Incremental Removal (%)
0.02	9.3%	0.49	100.0	9.3
0.04	9.5%	0.98	100.0	9.5
0.06	8.7%	1.47	100.0	8.7
0.08	10.1%	1.95	100.0	10.1
0.10	7.2%	2.44	100.0	7.2
0.12	6.0%	2.93	100.0	6.0
0.14	6.3%	3.42	100.0	6.3
0.16	5.6%	3.91	100.0	5.6
0.18	4.7%	4.40	100.0	4.7
0.20	3.6%	4.89	100.0	3.6
0.25	8.2%	6.11	100.0	8.2
0.50	14.9%	12.22	100.0	14.9
0.75	3.2%	18.32	94.7	3.1
1.00	1.2%	24.43	88.9	1.1
1.50	0.7%	36.65	77.5	0.6
2.00	0.8%	48.86	66.0	0.5
				99.3
			Removal Efficiency Adjustment[2] =	6.5%
			Predicted % Annual Rainfall Treated =	93.5%
			Predicted Net Annual Load Removal Efficiency =	**92.8%**

1 - Based on 10 years of rainfall data from NCDC station 736, Blue Hill, Norfolk County, MA

2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

Beaver Brook Farm
Drainage Basin #1
March 7, 2023

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = y). For a rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can change the distances from the center of the basin at which water-table aquifer thickness are calculated.
Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. The user MUST click the blue "Re-Calculate Now" button each time ANY of the user-specified inputs are changed otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

use consistent units (e.g. feet & days **or** inches & hours)

Input Values		
7.5300	***R***	**Recharge (infiltration) rate (feet/day)**
0.280	**Sy**	**Specific yield, Sy (dimensionless, between 0 and 1)**
165.40	**K**	**Horizontal hydraulic conductivity, Kh (feet/day)***
30.000	**x**	**1/2 length of basin (x direction, in feet)**
15.000	**y**	**1/2 width of basin (y direction, in feet)**
1.000	**t**	**duration of infiltration period (days)**
25.000	**hi(0)**	**initial thickness of saturated zone (feet)**

Conversion Table

inch/hour	**feet/day**
0.67	1.33
2.00	4.00

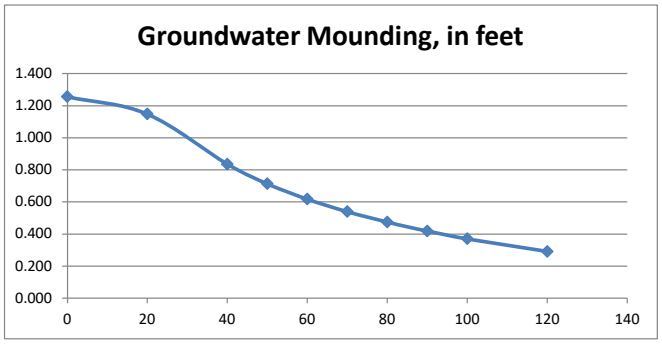
hours	**days**
36	1.50

In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).

26.255	**h(max)**	**maximum thickness of saturated zone (beneath center of basin at end of infiltration period)**
1.255	**Δh(max)**	**maximum groundwater mounding (beneath center of basin at end of infiltration period)**

Ground-water Mounding, in feet	**Distance from center of basin in x direction, in feet**
1.255	**0**
1.148	**20**
0.836	**40**
0.713	**50**
0.617	**60**
0.539	**70**
0.474	**80**
0.418	**90**
0.370	**100**
0.291	**120**

Re-Calculate Now



Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.

APPENDIX – D

Stormwater Operation and Maintenance Plan

and

Long Term Pollution Prevention Plan

Standard 9

Stormwater Management Operation and Maintenance Plan

Maintenance Agreement
Beaver Brook Farm
Holliston, Massachusetts

March 7, 2023
Revised: June 29, 2023

In accordance with Standard 9 of the Massachusetts Department of Environmental Protection Stormwater Handbook (February 2008), the attached on-site maintenance program for the proposed stormwater management system has been developed to ensure the Best Management Practices (BMP's) in place will remain functioning as designed. The Plan contains both construction period operations and maintenance as well as post construction responsibilities that shall "run" with the property if ownership is transferred.

Prior to Road Acceptance:
Land Owner/Operator:
Dennis Ferreira
734 Adams Street
Holliston, MA 01746
Phone: 508-429-8503

. .
Dennis Ferriera Date

Road Acceptance:
Operator:
Town of Holliston
Department of Public Works

Estimated Maintenance Yearly Budget:

Annual Catch Basin and CDS Units Cleaning:	$ 1,500.00
Mowing, vegetation maintenance of Drainage Basin:	$ 480.00
Repairs:	$ 250.00
Total	$ 2,230.00

Easements
Drainage Easements

Maintenance Logs shall be kept for minimum 3-years
Maintenance logs shall be made available to the Town of Holliston
Town of Holliston shall be allowed to inspect
Annual certification to be done.

Post-Construction Period Operation and Maintenance:

Safety:

Always keep safety considerations at the forefront of inspection procedures. Likely hazards should be anticipated and avoided. Never enter a confined space (outlet structure, manhole, etc) without proper training or equipment. A confined space should never be entered without at least one additional person present. If a toxic or flammable substance is discovered, leave the immediate area and contact the local authorities at 911.

All cast iron storm water structure grates and covers shall be kept in good condition and kept always closed. Any damaged or broken structures will be replaced immediately upon discovery.

Catch Basin and Manhole Maintenance:

Activity	Inspection Frequency
Inspect Units	2 Times per year
Clean Units	Whenever the depth of deposits is greater than ½ the sump depth (1 time per yr minimum)

Street Sweeping:

Activity	Inspection Frequency
Sweeping Paved surfaces	2 time per yr (spring & fall). Sweeping along South Street shall be done when necessary (no tracking of materials onto the street shall be allowed)

CDS Treatment Unit

Activity	Inspection Frequency
Inspect Inlet and Outlet	2 time per yr. After a heavy rain event 1" storm or larger
Inspect Access Ports for Sediment buildup & Cleanup	2 times per yr. Accumulated sediment buildup shall be Vacuumed cleaned as necessary

Drainage Basin:

Activity	Inspection Frequency
Sediment Removal	Inspect Monthly Remove accumulated sediment buildup Grass Mowing during growing season (Keep grasses no greater than 6 inches & no lower than 3 to 4 inches)

Stormwater Outlet Structure:

Activity	Inspection Frequency
Inspect Outlet	1 time per yr. Remove accumulated sediment buildup at outlet and overgrown vegetation around the outlet.

Stormwater Construction Site Inspection Report

General Information			
Project Name			
MA DEP File No.		**Location**	
Date of Inspection		**Start/End Time**	
Inspector's Name(s)			
Inspector's Title(s)			
Inspector's Contact Information			
Inspector's Qualifications			
Describe present phase of construction			
Type of Inspection: ❑ Regular ❑ Pre-storm event ❑ During storm event ❑ Post-storm event			
Weather Information			
Has there been a storm event since the last inspection? ❑Yes ❑No **If yes, provide:** Storm Start Date & Time: Storm Duration (hrs): Approximate Amount of Precipitation (in):			
Weather at time of this inspection? ❑ Clear ❑Cloudy ❑ Rain ❑ Sleet ❑ Fog ❑ Snowing ❑ High Winds ❑ Other: Temperature:			
Have any discharges occurred since the last inspection? ❑Yes ❑No **If yes, describe:**			
Are there any discharges at the time of inspection? ❑Yes ❑No **If yes, describe:**			

Site-specific BMPs

- *Number the structural and non-structural BMPs identified in your SWPPP on your site map and list them below (add as many BMPs as necessary). Carry a copy of the numbered site map with you during your inspections. This list will ensure that you are inspecting all required BMPs at your site.*
- *Describe corrective actions initiated, date completed, and note the person that completed the work in the Corrective Action Log.*

	BMP	BMP Installed?	BMP Maintenance Required?	Corrective Action Needed and Notes
1		❑Yes ❑No	❑Yes ❑No	
2		❑Yes ❑No	❑Yes ❑No	
3		❑Yes ❑No	❑Yes ❑No	
4		❑Yes ❑No	❑Yes ❑No	
5		❑Yes ❑No	❑Yes ❑No	
6		❑Yes ❑No	❑Yes ❑No	
7		❑Yes ❑No	❑Yes ❑No	
8		❑Yes ❑No	❑Yes ❑No	
9		❑Yes ❑No	❑Yes ❑No	
10		❑Yes ❑No	❑Yes ❑No	
11		❑Yes ❑No	❑Yes ❑No	

	BMP	BMP Installed?	BMP Maintenance Required?	Corrective Action Needed and Notes
12		❑Yes ❑No	❑Yes ❑No	
13		❑Yes ❑No	❑Yes ❑No	
14		❑Yes ❑No	❑Yes ❑No	
15		❑Yes ❑No	❑Yes ❑No	
16		❑Yes ❑No	❑Yes ❑No	
17		❑Yes ❑No	❑Yes ❑No	
18		❑Yes ❑No	❑Yes ❑No	
19		❑Yes ❑No	❑Yes ❑No	
20		❑Yes ❑No	❑Yes ❑No	

Overall Site Issues

Below are some general site issues that should be assessed during inspections. Customize this list as needed for conditions at your site.

	BMP/activity	Implemented?	Maintenance Required?	Corrective Action Needed and Notes
1	Are all slopes and disturbed areas not actively being worked properly stabilized?	❑Yes ❑No	❑Yes ❑No	
2	Are natural resource areas (e.g., streams, wetlands, mature trees, etc.) protected with barriers or similar BMPs?	❑Yes ❑No	❑Yes ❑No	
3	Are perimeter controls and sediment barriers adequately installed (keyed into substrate) and maintained?	❑Yes ❑No	❑Yes ❑No	
4	Are discharge points and receiving waters free of any sediment deposits?	❑Yes ❑No	❑Yes ❑No	
5	Are storm drain inlets properly protected?	❑Yes ❑No	❑Yes ❑No	
6	Is the construction exit preventing sediment from being tracked into the street?	❑Yes ❑No	❑Yes ❑No	
7	Is trash/litter from work areas collected and placed in covered dumpsters?	❑Yes ❑No	❑Yes ❑No	
8	Are washout facilities (e.g., paint, stucco, concrete) available, clearly marked, and maintained?	❑Yes ❑No	❑Yes ❑No	

	BMP/activity	Implemented?	Maintenance Required?	Corrective Action Needed and Notes
9	Are vehicle and equipment fueling, cleaning, and maintenance areas free of spills, leaks, or any other deleterious material?	❑Yes ❑No	❑Yes ❑No	
10	Are materials that are potential stormwater contaminants stored inside or under cover?	❑Yes ❑No	❑Yes ❑No	
11	Are non-stormwater discharges (e.g., wash water, dewatering) properly controlled?	❑Yes ❑No	❑Yes ❑No	
12	(Other)	❑Yes ❑No	❑Yes ❑No	

Non-Compliance

Describe any incidents of non-compliance not described above:

CERTIFICATION STATEMENT

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Print name and title: _____

Signature:_____ **Date:**_____

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CDS® Inspection and Maintenance Guide

CDS TECHNOLOGIES

Maintenance

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

Inspection

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

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

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

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

Cleaning

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

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

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

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

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Support

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

Contech Engineered Solutions LLC provides site solutions for the civil engineering industry. Contech's portfolio includes bridges, drainage, sanitary sewer, stormwater, earth stabilization and wastewater treament products. For information, visit www.ContechES.com or call 800.338.1122

The product(s) described may be protected by one or more of the following US patents: 5,322,629; 5,624,576; 5,707,527; 5,759,415; 5,788,848; 5,985,157; 6,027,639; 6,350,374; 6,406,218; 6,641,720; 6,511,595; 6,649,048; 6,991,114; 6,998,038; 7,186,058; 7,296,692; 7,297,266; 7,517,450 related foreign patents or other patents pending.

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CDS Inspection & Maintenance Log

CDS Model: _____ Location: _____

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

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

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

Stormwater Management Operation and Maintenance Plan And Long Term Pollution Prevention Plan

Maintenance Agreement
Beaver Brook Farm
Holliston, Massachusetts

March 7, 2023

In accordance with Standard 9 of the Massachusetts Department of Environmental Protection Stormwater Handbook (February 2008), the attached on-site maintenance program for the proposed stormwater management system has been developed to ensure the Best Management Practices (BMP's) in place will remain functioning as designed. The landowner/operator, or its successors, of the Project Site, Lincoln Estates, (Assessor Map 38, Parcels 23 & 24), shall be responsible for financing maintenance and emergency repairs of the entire stormwater management system on the property. The Plan contains both construction period operations and maintenance as well as post construction responsibilities that shall "run" with the property when the ownership is transferred.

Responsible Operator:
Dennis Ferreira
734 Adams Street
Holliston, MA 01746
508-429-8503

Construction Period Operation and Maintenance:

- It should be noted that the US EPA mandated NPDES stormwater program requires construction site operators engaged in clearing, grading, and excavating activities that disturb 1 acre or more, including smaller sites in a larger common plan of development or sale, to obtain coverage under an NPDES permit for their stormwater discharges. The Project is subject to this permit and therefore, a Stormwater Pollution Prevention Plan (SWPPP) will be prepared prior to commencement of construction. The SWPPP will contain additional construction period and post construction erosion control requirements.

Good Housekeeping Practices:

- Remove all debris from site and dispose of in trash dumpsters
- Plan for adequate disposal of scrap, waste and surplus materials
- Keep work area clean
- Secure loose or light material that is stored on the site
- Store flammable materials apart from other materials
- Secure all materials at the end of each work day
- Maintain a clean neat and orderly site

Safety:

Always keep safety considerations at the forefront of inspection procedures. Likely hazards should be anticipated and avoided. Never enter a confined space (outlet structure, manhole, etc) without proper training or equipment. A confined space should never be entered without at least one additional person present. If a toxic or flammable substance is discovered, leave the immediate area and contact the local authorities at 911.

All cast iron storm water structure grates and covers shall be kept in good condition and kept always closed. Any damaged or broken structures will be replaced immediately upon discovery.

Subsurface Infiltration Chambers:

Rope or fence off the area selected for the infiltration chambers. Stabilize the site prior to installing the subsurface chambers. Do not allow runoff from any disturbed areas on site to flow to the chambers. Never allow construction equipment not performing the excavation to drive across the area where the chambers will be installed. Provide an access port, manway, and an observation well to enable inspection of water levels within the system. Make the observation well pipe visible at grade. *See Homeowners Operation and Maintenance*

Erosion Control Barriers:

Filtermitts in combination with construction fencing shall be installed where indicated on the plans and in other appropriate locations where warranted. These barriers shall be installed prior to the commencement of any work on-site and in accordance with the construction plans. A supply of filtermitts shall be kept on-site to replace and/or repair barriers that are damaged or degraded. The barriers shall be observed and maintained on a weekly basis during construction.

Construction Entrances:
The purpose of stabilizing entrances to a construction site is to minimize the amount of sediment leaving the area as mud and sediment attached to vehicles. The entrances shall be sized according to the Massachusetts DEP and US EPA guidelines and will be maintained on a weekly basis during construction. A Detail is included in the Site Plans prepared for the Project.

Sediment Traps/Basins:
Sediment basins and rock dams can be used to capture sediment from stormwater runoff before it leaves a construction site. Both structures allow a pool to form in an excavated or natural depression, where sediment can settle. The pool is dewatered through a single riser and drainage hole leading to a suitable outlet on the downstream side of the embankment or through the gravel of the rock dam. Design a sediment trap to maximize the surface area for infiltration and sediment settling. This increases the effectiveness of the trap and decreases the likelihood of backup during and after periods of high runoff intensity. Site conditions dictate specific design criteria, but the minimum storage capacity should be 1,800 ft^3 per acre of total drainage area (Smolen et al., 1988). The volume of a natural sediment trap can be approximated using the following equation (Smolen et al., 1988): *Volume (ft^3) = 0.4 x surface area (ft^2) x maximum pool depth (ft).* Sediment traps have a useful life of about 18 to 24 months (USEPA, 1993), but their effectiveness depends on the amount and intensity of rainfall and erosion, and proper maintenance.

Dust Control:
Soils information for the site indicates that it is comprised of sandy soils. Therefore, Dust control BMPs to reduce surface activities and air movement that causes dust to be generated from disturbed soil surfaces will be required. The preferred measure for dust control is sprinkling/irrigation. This is an on-going/as-needed requirement until surfaces have been stabilized. There shall be a water truck on-site available as needed.

Diversions:
Temporary diversion swales and mounds will be constructed to divert stormwater away from areas under construction to limit sediment transport. These diversions will be relocated as construction progresses. Stone check dams will be installed in swales as necessary to limit scour and sediment transport.

Catch Basin Protection:
Temporary inlet protection barriers consisting of Silt Sacks® will be placed within all constructed inlets to prevent inflow of sediments into the constructed drainage system. The barriers shall remain in place until a permanent cover is established or diversions away from the inlets are constructed. The barriers shall be observed and maintained as necessary on a weekly basis and after every rainfall of 0.5 inches or more.

Drainage Basins:
During Construction, the basins shall be observed during and after all storm events to ensure there is no sediment accumulation or degradation of infiltrative surfaces. The basin bottoms shall be maintained at an elevation at least 1-foot above the proposed finished bottom elevation to protect final infiltrative surfaces. The basins will be excavated to final grades after all surfaces contributing

runoff to the basins have been stabilized. Ensure all stumps are fully removed from the area of the system to ensure proper function. Care should be taken by the contractor to prevent compaction of the final basin bottom. Use deep tilling to break up compacted surfaces, should it occur.

Spill Control:

A contingency plan to address the spillage/release of petroleum products and any hazardous materials will be implemented for the site during construction. The plan will include the following measures:

- Equipment necessary to quickly attend to inadvertent spills or leaks shall be on-site in a secure but accessible location. Such equipment will include, but not be limited to, the following: urethane drain cover seals (mats), a spill containment kit which includes sand and shovels, suitable absorbent materials, storage containers, safety goggles, chemically resistant gloves and overshoe boots, water and chemical fire extinguishers, and first aid equipment.
- Spills or leaks will be treated properly according to material type, volume of spillage and location of spill. Mitigation will include preventing further spillage, containing the spilled material to the smallest practical area, removing spilled material in a safe and environmentally friendly manner, and remediating any damage to the environment.
- The contractor shall be familiar with the reporting requirements of the Massachusetts Contingency Plan (310 CMR 40.00) as issued by the Massachusetts Department of Environmental Protection (DEP); specifically Subpart C Notification of Releases and Threats of Release of Oil and Hazardous Materials and Subpart D Preliminary Response Activities and Risk Reduction Measures.
- For any large spills. The Massachusetts DEP Hazardous Waste Incident Response Group shall be notified immediately at 1-617-792-7653 and an emergency response contractor will be called in.

APPENDIX – E

Illicit Discharge Statement

Standard 10

Illicit Discharge Compliance Statement

Beaver Brook Farm
Definitive Subdivision Plan
Holliston, Massachusetts

March 7, 2023

This statement is provided in accordance with the provisions of the Massachusetts Stormwater Management Standard #10.

To the best of the applicant's/owners knowledge there are no illicit discharges to the site's stormwater manangement system.

All proposed uses on the site will not generate, store or discharge any pollutants to the groundwater and/or wetland resource areas.

Any illicit discharges identified during or after construction will be terminated immediately.

Applicant/Owner:

Dennis Ferriera
784 Adams Street
Holliston, MA 01746
Phone: 508-429-8503

APPENDIX – G

Supplemental Stormwater Plans

Pre-Development Subcatchment Areas
Post-Development Subcatchment Areas
Hydraulic Subcatchment Areas

N/F
DAVID KURZONTKOWSKI

N/F
RICHARD & LAURA KURZONTKOWSKI

N/F
PAULA KURZONTKOWSKI

N/F
RICHARD & LINDA SOHN

TOWN OF HOLLISTON

N74°35'56"E 127.23'

N89°35'43"E 660.11'

N89°20'21"E 145.07'

N89°20'21"E 120.25'

N47°42'00"E 1.96'

N79°18'37"E 59.78'

S27°05'50"E 189.75'

S35°33'00"E 75.50'

S70°15'24"W 283.20'(TOT)

S38°03'41"E 341.75'

S13°39'17"W 39.82'

N83°39'10"W 497.97'

N85°56'50"W 301.49'

N85°45'47"W 157.50'

E4 — INDOOR RIDING ARENA

1E

1P — POND

3E

1R

2E

DP1 — DESIGN POINT#1

100' WETLAND BUFFER

50' WETLAND BUFFER

Tc FLOW PATH

ASSESSOR'S REFERENCE:
MAP 4, BLOCK 2, PARCEL 58

DEED REFERENCE:
MIDDLESEX SOUTH COUNTY REGISTRY OF DEEDS
Bk. 57029, Pg. 384

PLAN REFERENCE:
PLAN No. 1103 OF 1981, Bk. 14430, Pg. 1

OWNER OF RECORD:
YVONNE & DENNIS FERREIRA, Jr.
734 ADAMS STREET
HOLLISTON, MA 01746

ZONING CLASSIFICATION:
AGRICULTURAL-RESIDENTIAL A
MIN. LOT SIZE: 80,000 S.F.
MIN. FRONTAGE: 225'
MIN. DEPTH: 300'
SETBACKS:
FRONT: 40'
SIDE: 40'
REAR: 40'

OPEN SPACE INTENSITY REGULATIONS:
AGRICULTURAL-RESIDENTIAL A
MIN. LOT AREA: 20,000 S.F.
MIN. FRONTAGE: 50 FT.
SETBACKS:
FRONT: 30'
SIDE: 10'
REAR: 10'
MAX LOT COVERAGE: 25%

PRE-DEVELOPED RUNOFF AREAS

GRAPHIC SCALE
40 0 20 40 80 160
(IN FEET)
1 inch = 40 ft.

REVISIONS		
No.	DATE	DESCRIPTION

FLD.:
DRW.:
CHKD.:

GLM Engineering Consultants, Inc.
19 EXCHANGE STREET
HOLLISTON, MA 01746
P: 508-429-1100 F: 508-429-7160
www.GLMengineering.com

DEFINITIVE OPEN SPACE SUBDIVISION
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A 7 LOT SINGLE FAMILY SUBDIVISION
HOLLISTON, MASSACHUSETTS
PREPARED FOR:
YVONNE & DENNIS FERREIRA, Jr.
734 ADAMS STREET
HOLLISTON, MASSACHUSETTS

JOB No.	9936-2022
DATE:	MARCH 6, 2023
SCALE:	1"=40'
SHEET:	1 of 3
PLAN #:	27,816

ASSESSOR'S REFERENCE:
MAP 4, BLOCK 2, PARCEL 58

DEED REFERENCE:
MIDDLESEX SOUTH COUNTY REGISTRY OF DEEDS
Bk. 57029, Pg. 384

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MIN. LOT AREA: 20,000 S.F.
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SETBACKS:
FRONT: 30'
SIDE: 10'
REAR: 10'
MAX LOT COVERAGE: 25%

POST-DEVELOPED RUNOFF AREAS

GRAPHIC SCALE
40 0 20 40 80 160
(IN FEET)
1 inch = 40 ft.

REVISIONS		
No.	DATE	DESCRIPTION

FLD.:
DRW.:
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JOB No.	9936-2022
DATE:	MARCH 6, 2023
SCALE:	1"=40'
SHEET:	2 of 3
PLAN #:	27,816

ASSESSOR'S REFERENCE:
MAP 4, BLOCK 2, PARCEL 58

DEED REFERENCE:
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Bk. 57029, Pg. 384

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