DRAINAGE REPORT

Hillsdale College
732 Hall Hill Road
Somers, CT

Revised January 23, 2020

Prepared for:

Hillsdale College
33 East College Street
Hillsdale, MI 49242

Project No. 2019-056

Prepared by:

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I. *INTRODUCTION*

A. *Project Description*

Hillsdale College is proposing to renovate the existing home at 732 Hall Hill Road in Somers to a religious institution space for holding seminars and conferences. Associated site improvements will include the construction of a new driveway, a new 30 space parking lot, and expansion of the area in front of the garage to provide two handicap parking spaces. Runoff from the proposed parking area will be collected and diverted through a hydrodynamic separator for treatment and a subsurface retention system to recharge some runoff back into the ground and ensure that the post development peak discharge from the site does not exceed the pre-development level.

B. *Existing Conditions*

The subject parcel consists both the properties at 732 and 740 Hall Hill Road on the east side of Hall Hill Road across from Meadow Brook Road in Somers, Connecticut. The parcel at 732 Hall Hill Road consists of 8.16 acres currently improved with a large single-family home accessed by a 12-foot wide driveway and two existing curb cuts off of Hall Hill Road. The house is served by a private well located in the front yard and a subsurface sewage disposal system located in the rear yard. A horse paddock and two sheds exist at the eastern end of the parcel. An intermittent stream and its associated wetland flow across the southern end of the parcel before turning north and flowing into Massachusetts just east of the paddock area. The parcel at 740 Hall Hill Road abuts 732 Hall Hill Road to the northwest. This parcel was also the location of a single-family home and several outbuildings. However, all of the buildings on this parcel were recently razed. With the exception of the houses, drives and paddock, the remaining areas of both parcels are maintained as manicured lawns.

The house at 732 Hall Hill Road is located on the crest of a hill. Runoff from areas to the west, south and east of the house sheet flow across the lawn and eventually make it to the intermittent stream. Runoff from the northern and northwestern portion of the subject site, including 740 Hall Hill Road, sheet flows toward the northwest corner of the site.

Based on a review of the USDA Soil Survey of Hartford County, site soils in the vicinity of the house are classified as Urban Land complex (developed areas), soils to the east of the house are classified as Cheshire fine sandy loam, and soils along Hall Hill Road and to the northwest are classified as Watching fine sandy loam (See Soils Map in Appendix 1). The USDA Soil Survey defines groups of soils into Hydrologic Soil Groups (HSG) according to their runoff-producing characteristics. Soils are assigned to four groups (A, B, C, and D Groups). In group A, are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They typically are deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a hardpan or clay layer at or near the surface, have a permanent high-water table, or are shallow over nearly impervious bedrock or other nearly impervious material. The HSG classification of

Urban Land and Cheshire soils are HSG B. The HSG classification of Watching soils is HSG C.

Two test pits were conducted on December 31, 2019 to confirm soil conditions at two locations being considered for stormwater management basins, one at the front of the site and one at the rear. The test pit locations and results are provided on Sheet 1 of the plan set. The test pit in the paddock area at the rear of the parcel (TP1) confirmed the presence of fill over the historical topsoil layer, over fine sandy loam, over sand and gravel. The material encountered appears to be a better draining material than what is expected for Cheshire fine sandy loam. Evidence of the seasonal high water table in the test pit in the form of mottling was encountered at a depth of 24 inches which corresponds to an approximate elevation of 265. The test pit at the front of the site (TP2) confirmed the presence of topsoil over, fine sandy loam over fine sands and ultimately sand and gravel. Again, the soils encountered appeared to be a better draining sandier material than what is expected from the Watchaug fine sandy loam. No evidence of the water table was detected in this test pit to a depth of 6 feet.

II. STORMWATER RUNOFF ANALYSIS

A. Methodology

The peak runoff flow rates for the 2-year, 10-year, 25-year and 100-year, 24-hour design storms were determined for pre- and post-development conditions using Applied Microcomputer System's HydroCAD™ Stormwater Modeling System. This computer software employs the SCS Technical Release 55 and 20 (TR-55 & TR-20) methodology.

Two design points were selected in order to determine allowable release rates from the proposed stormwater management systems. Design point DP1 is the edge of the existing intermittent stream to the east of the subject parcel. Design point DP2 is where runoff discharges across the northwest corner of the subject site. Design point locations are shown on the Drainage Area Maps in Appendix 2.

B. Pre-Development Hydrology

The pre-development area was divided into two (2) sub catchments as shown on the Pre-Development Drainage Area Map in Appendix 1. Subcatchment 1 includes the central, eastern and southern portions of the subject site that drains easterly toward the intermittent stream (design point DP1). Subcatchment 2 includes the northwestern portion of the site that contributes runoff across the northwestern property boundary (design point DP2). Pre-development runoff characteristics for each of the subcatchments are provided in Appendix 3. A summary of the calculated peak flows is provided in Table 1 below.

C. *Post-Development Hydrology*

The proposed project will involve the widening of the existing northern driveway to 20-feet to accommodate two-way traffic, extending the driveway to a new 30-space parking lot at the rear of the parcel, and the expansion of the paved area in front of the garage for two handicap parking spaces. Th eastern portion of the driveway and parking lot will be curbed on the low side to direct runoff to a new stormwater inlet located in the parking lot. This inlet will consist of a CDS 2015-4-C stormwater treatment unit by Con-tech Engineered Solutions, Inc. The treatment unit will discharge to a subsurface retention system comprised of 56 – 4'x8'x2.5' concrete retain-it chambers designed to provide a storage capacity of approximately 7,764 cubic feet. Flow through the detention system will be controlled via an outlet structure equipped with a low flow orifice and a concrete weir. The outlet structure will discharge via a 50' level spreader to the area downstream outside of the regulated area associated with the intermittent stream. Details of the detention system, outlet structure and level spreader have been added to the detail sheets of the plan set.

The design points selected for calculations of the pre-development condition are also used for the calculations of the post-development condition. The post development site is divided into 3 subcatchments as shown on the Post Development Drainage Area Map in Appendix 2. Subcatchment 1A includes the northern and eastern and southern portions of the subject site that will continue to drain directly to the intermittent stream (DP1). Subcatchment 1B includes the eastern portion of the driveway and parking lot, that will be routed through the new subsurface retention facility prior to discharge to the stream (DP1). Subcatchments 2 includes the northwestern portion of the subject site that will continue to sheet flow directly across the northwestern property line (DP2). The post development subcatchment characteristics are summarized in the attached HydroCAD data sheets in Appendix 3. To be conservative, any infiltration provided in the retention system was ignored.

Using the characteristics described above, the Post Development peak flow rates for the site were calculated for the design storms. Refer to Appendix 3 for HydroCAD data sheets. Table 1 below compares the pre-development peak flows with the post-development peak flows at the design points. The resulting post-development peak flows are less than or equal to the pre-development peak flows at the design points.

TABLE 1 - PEAK FLOW COMPARISON

Design Point	2-Year		10-Year		25-Year		100-Year	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	1.7	1.7	5.1	4.5	7.3	6.3	11.4	11.3
2	1.5	1.4	3.4	3.3	4.6	4.4	6.8	6.6

D. Pipe Sizing

All piping proposed at the site consists of smooth bore high density polyethylene corrugated plastic pipe with a smooth bore (CPEP-S). The roughness coefficient used for this pipe type is 0.012. The analysis provided in Appendix 3 indicates headwater elevation at each pipe inlet for the design storms. The results for CDS1 provide the resulting headwaters upstream of the inlet pipe to the basin, while the results for 2P provide the resulting headwaters in the subsurface retention system prior to the outlet pipe. The calculations indicate that the basin inlet pipe has sufficient capacity to convey the 25-year design storm without overtopping the catch basin grate. Likewise, the retention system outlet pipe has sufficient capacity to convey the 100-year design storm without exceeding the capacity of the system. In both cases, the pipe capacity exceeds the Town's requirement for the 10-year design storm.

E. Treatment

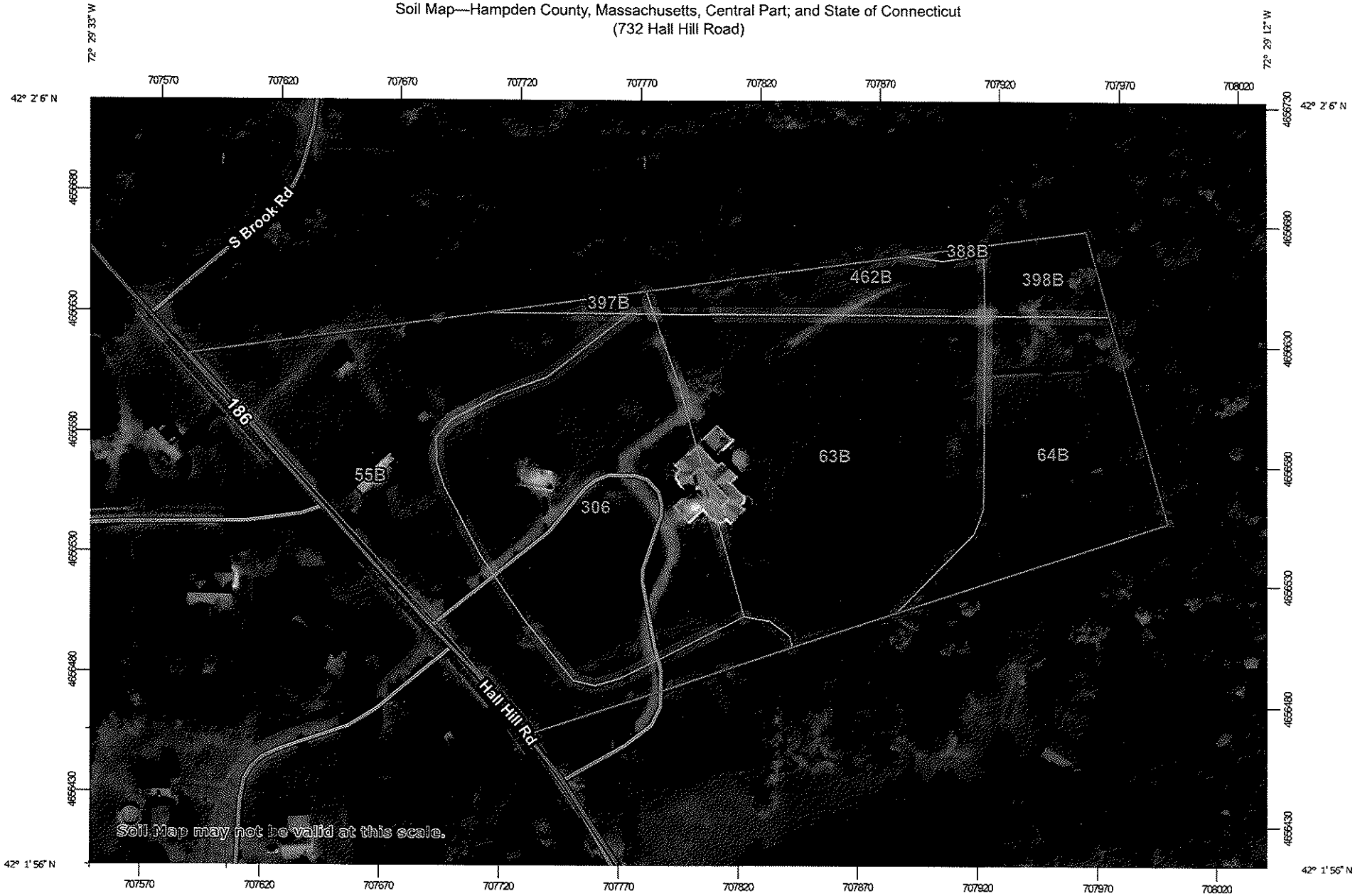
The proposed stormwater treatment unit was designed and sized to accommodate the required Water Quality Flow (WQF) for the contributing area in accordance with the CT Stormwater Quality Manual. It is designed to remove oils and floatables, as well as a minimum 80% of total suspended solids. Sizing calculations for this unit are provided in Appendix 4.

F. Summary of Results

The proposed design and analysis indicate that there will be no increase in peak runoff off from the site for the indicated design storms. In addition, the treatment measures discussed will provide pollutant removal prior to discharge of stormwater to the surrounding wetlands and watercourse.

Appendix 1:
SOILS INFORMATION

Soil Map—Hampden County, Massachusetts, Central Part; and State of Connecticut
(732 Hall Hill Road)



Map Scale: 1:2,250 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 30 60 120 180

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:12,000 to 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: Hampden County, Massachusetts, Central Part
Survey Area Data: Version 13, Sep 12, 2019

Soil Survey Area: State of Connecticut
Survey Area Data: Version 19, Sep 13, 2019

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: Mar 15, 2016—Oct 30, 2017

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
388B	Wilbraham silt loam, 3 to 8 percent slopes, extremely stony	0.0	0.2%
397B	Wethersfield fine sandy loam, 3 to 8 percent slopes	0.1	0.6%
398B	Wethersfield fine sandy loam, 3 to 8 percent slopes, very stony	0.4	3.0%
462B	Cheshire fine sandy loam, 3 to 8 percent slopes	0.6	5.1%
Subtotals for Soil Survey Area		**1.1**	**9.0%**
Totals for Area of Interest		**12.6**	**100.0%**

C/D
C
C
A

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
55B	Watchaug fine sandy loam, 3 to 8 percent slopes	3.1	24.6%
63B	Cheshire fine sandy loam, 3 to 8 percent slopes	3.6	28.5%
64B	Cheshire fine sandy loam, 3 to 8 percent slopes, very stony	1.7	13.8%
306	Udorthents-Urban land complex	3.0	24.2%
Subtotals for Soil Survey Area		**11.5**	**91.0%**
Totals for Area of Interest		**12.6**	**100.0%**

C
B
B
B

State of Connecticut

55B—Watchaug fine sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 9lpb
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 52 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Watchaug and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Watchaug

Setting

Landform: Hills, till plains
Down-slope shape: Linear
Across-slope shape: Concave
Parent material: Coarse-loamy melt-out till derived from basalt and/or sandstone and shale

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 18 inches: fine sandy loam
Bw2 - 18 to 24 inches: fine sandy loam
C - 24 to 65 inches: gravelly sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C
Hydric soil rating: No

Minor Components

Cheshire

Percent of map unit: 5 percent
Landform: Hills, till plains
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Wilbraham

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Ludlow

Percent of map unit: 3 percent
Landform: Drumlins, hills
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Unnamed, stony surface

Percent of map unit: 3 percent
Hydric soil rating: No

Unnamed, silt loam surface

Percent of map unit: 2 percent
Hydric soil rating: No

Menlo

Percent of map unit: 2 percent
Landform: Depressions, drainageways
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Data Source Information

Soil Survey Area: State of Connecticut
Survey Area Data: Version 19, Sep 13, 2019

State of Connecticut

63B—Cheshire fine sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 9lpw
Elevation: 0 to 1,200 feet
Mean annual precipitation: 43 to 54 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 140 to 185 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Cheshire and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Cheshire

Setting

Landform: Hills, till plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy melt-out till derived from basalt and/or sandstone and shale

Typical profile

Ap - 0 to 8 inches: fine sandy loam
Bw1 - 8 to 16 inches: fine sandy loam
Bw2 - 16 to 26 inches: fine sandy loam
C - 26 to 65 inches: gravelly sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Hydric soil rating: No

Minor Components

Wilbraham
Percent of map unit: 5 percent
Landform: Drainageways, depressions
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Yalesville
Percent of map unit: 3 percent
Landform: Ridges, hills
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Wethersfield
Percent of map unit: 3 percent
Landform: Drumlins, hills
Down-slope shape: Linear
Across-slope shape: Convex
Hydric soil rating: No

Watchaug
Percent of map unit: 3 percent
Landform: Hills, till plains
Down-slope shape: Linear
Across-slope shape: Concave
Hydric soil rating: No

Unnamed, brown subsoil
Percent of map unit: 2 percent
Hydric soil rating: No

Menlo
Percent of map unit: 2 percent
Landform: Drainageways, depressions
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Unnamed, less sloping
Percent of map unit: 2 percent
Hydric soil rating: No

Data Source Information

Soil Survey Area: State of Connecticut
Survey Area Data: Version 19, Sep 13, 2019

State of Connecticut

306—Udorthents-Urban land complex

Map Unit Setting

National map unit symbol: 9lmg
Elevation: 0 to 2,000 feet
Mean annual precipitation: 43 to 56 inches
Mean annual air temperature: 45 to 55 degrees F
Frost-free period: 120 to 185 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 50 percent
Urban land: 35 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Setting

Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Drift

Typical profile

A - 0 to 5 inches: loam
C1 - 5 to 21 inches: gravelly loam
C2 - 21 to 80 inches: very gravelly sandy loam

Properties and qualities

Slope: 0 to 25 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to high (0.00 to 1.98 in/hr)
Depth to water table: About 54 to 72 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: Moderate (about 6.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Hydric soil rating: No

Description of Urban Land

Typical profile

H - 0 to 6 inches: material

Interpretive groups

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

Minor Components

Unnamed, undisturbed soils

Percent of map unit: 8 percent
Hydric soil rating: No

Udorthents, wet substratum

Percent of map unit: 5 percent
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

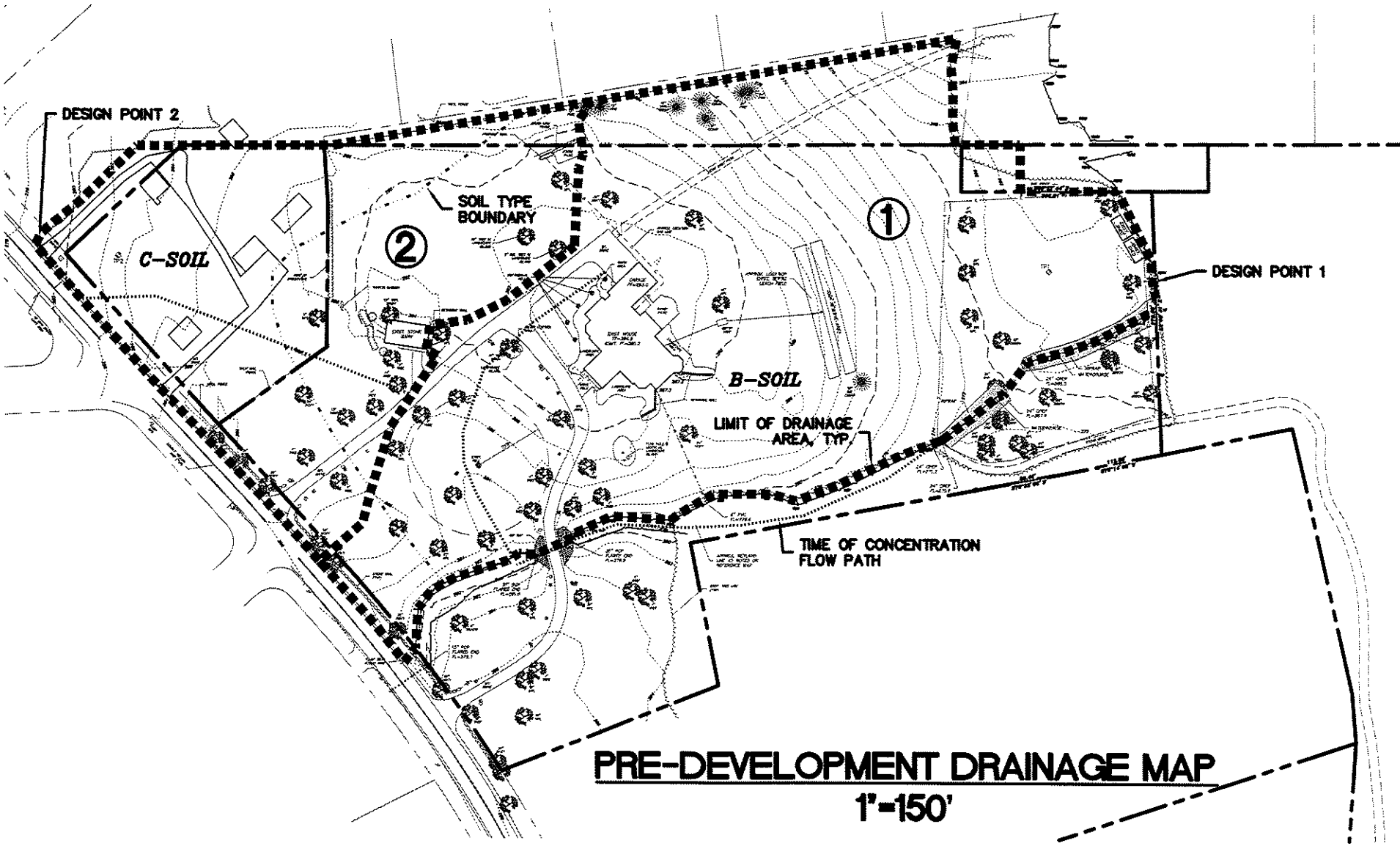
Rock outcrop

Percent of map unit: 2 percent
Hydric soil rating: No

Data Source Information

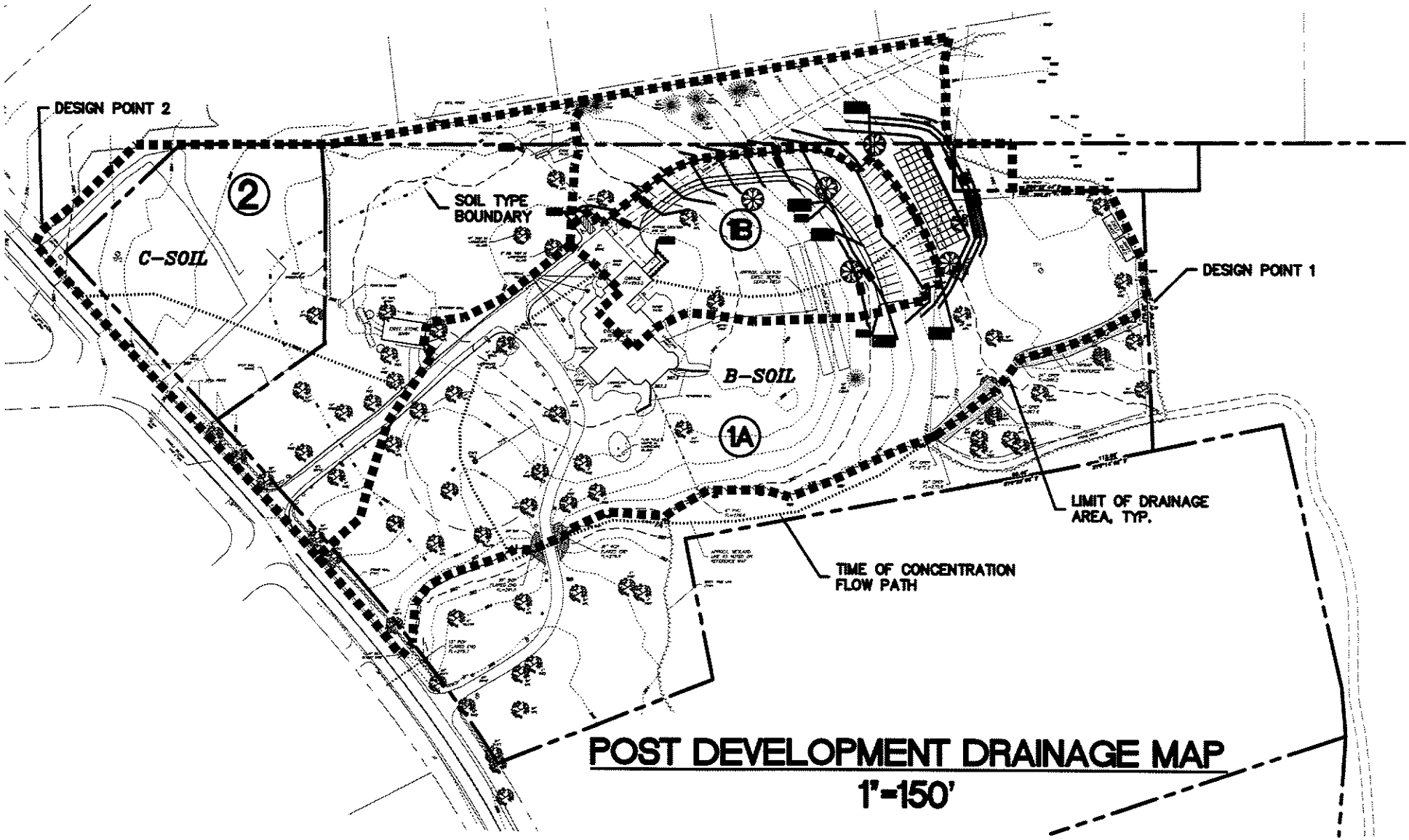
Soil Survey Area: State of Connecticut
Survey Area Data: Version 19, Sep 13, 2019

Appendix 2:
FIGURES



PRE-DEVELOPMENT DRAINAGE MAP

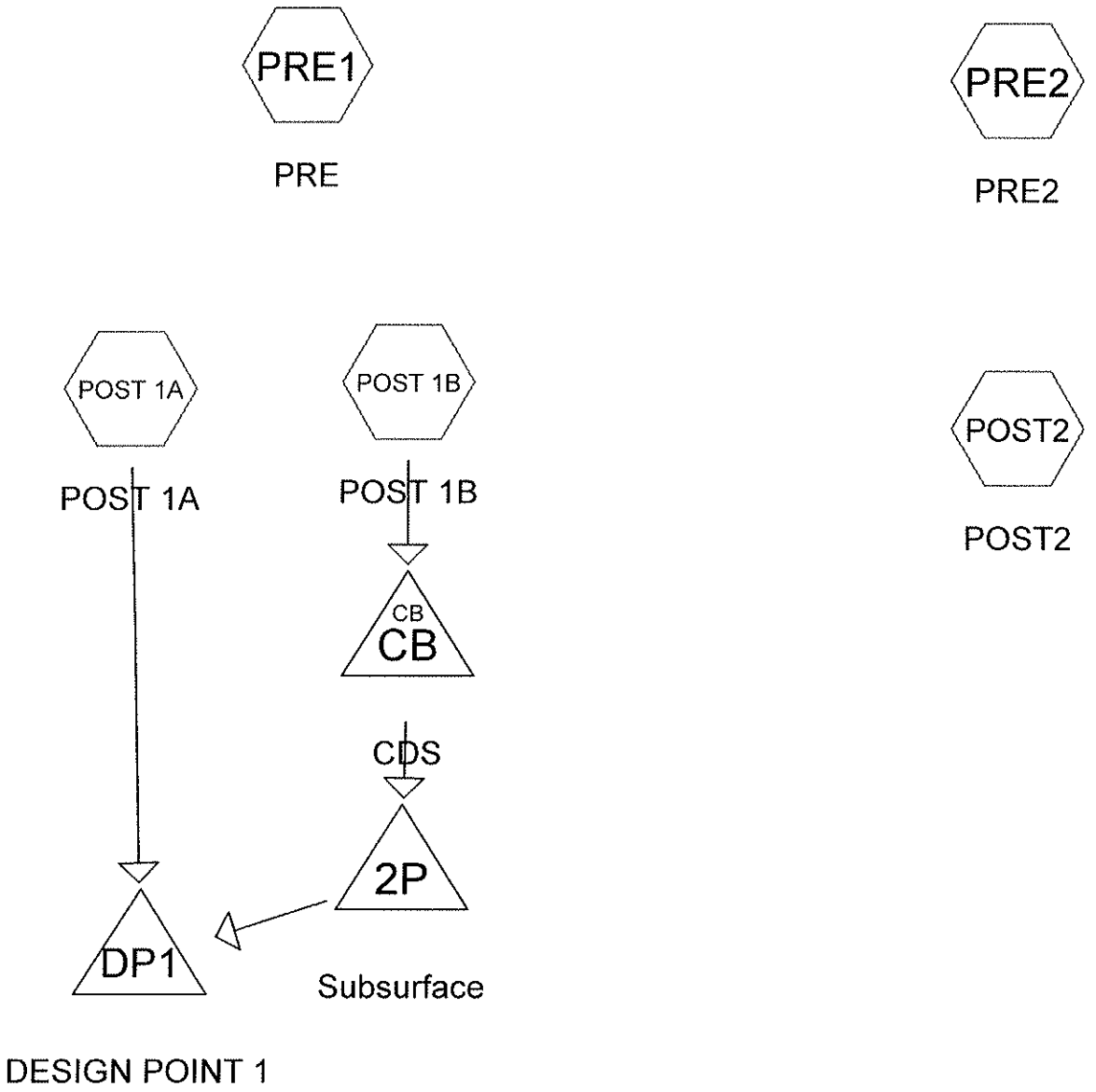
1"=150'



POST DEVELOPMENT DRAINAGE MAP

1"=150'

Appendix 3:
HYDROCAD ANALYSES



Subcat Reach Pond Link

Routing Diagram for 2019-056 Blake Revised
Prepared by {enter your company name here}, Printed 1/23/2020

Time span=2.00-72.00 hrs, dt=0.02 hrs, 3501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment POST 1A: POST 1A Runoff Area=224,833 sf 6.29% Impervious Runoff Depth=1.91"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=5.81 cfs 0.823 af

Subcatchment POST 1B: POST 1B Runoff Area=56,516 sf 43.82% Impervious Runoff Depth=3.05"
Flow Length=318' Tc=17.3 min CN=77 Runoff=3.31 cfs 0.329 af

Subcatchment POST2: POST2 Runoff Area=148,798 sf 3.95% Impervious Runoff Depth=2.41"
Flow Length=440' Tc=44.8 min CN=70 Runoff=4.42 cfs 0.687 af

Subcatchment PRE1: PRE Runoff Area=281,349 sf 6.45% Impervious Runoff Depth=1.91"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=7.28 cfs 1.030 af

Subcatchment PRE2: PRE2 Runoff Area=148,798 sf 9.84% Impervious Runoff Depth=2.50"
Flow Length=440' Tc=44.8 min CN=71 Runoff=4.60 cfs 0.712 af

Pond 2P: Subsurface Peak Elev=271.53' Storage=6,274 cf Inflow=3.31 cfs 0.329 af
Outflow=0.57 cfs 0.329 af

Pond CB: CDS Peak Elev=271.53' Inflow=3.31 cfs 0.329 af
15.0" Round Culvert n=0.012 L=8.0' S=0.0125 '/' Outflow=3.31 cfs 0.329 af

Pond DP1: DESIGN POINT 1 Inflow=6.34 cfs 1.152 af
Primary=6.34 cfs 1.152 af

Summary for Subcatchment POST 1A: POST 1A

Runoff = 5.81 cfs @ 12.52 hrs, Volume= 0.823 af, Depth= 1.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	198,267	61	>75% Grass cover, Good, HSG B
	10,319	74	>75% Grass cover, Good, HSG C
*	14,147	98	Impervious
*	2,100	88	Dirt Path, HSG C
	224,833	64	Weighted Average
	210,686		93.71% Pervious Area
	14,147		6.29% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.2	96	0.0100	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
0.5	22	0.0100	0.77		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.20"
8.3	82	0.0520	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
2.6	182	0.0280	1.17		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.9	484	0.0230	2.06	10.28	**Trap/Vee/Rect Channel Flow,** Bot.W=2.00' D=1.00' Z= 3.0 '/' Top.W=8.00' n= 0.078
1.8	260	0.0300	2.39	9.58	**Trap/Vee/Rect Channel Flow,** Bot.W=2.00' D=1.00' Z= 2.0 '/' Top.W=6.00' n= 0.078 Riprap, 12-inch
35.3	1,126	Total			

Summary for Subcatchment POST 1B: POST 1B

Runoff = 3.31 cfs @ 12.24 hrs, Volume= 0.329 af, Depth= 3.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	31,748	61	>75% Grass cover, Good, HSG B
*	24,768	98	Impervious
	56,516	77	Weighted Average
	31,748		56.18% Pervious Area
	24,768		43.82% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.7	200	0.0540	0.20		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
0.3	38	0.1000	2.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.3	80	0.0500	4.54		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
17.3	318	Total			

Summary for Subcatchment POST2: POST2

Runoff = 4.42 cfs @ 12.64 hrs, Volume= 0.687 af, Depth= 2.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	85,738	74	>75% Grass cover, Good, HSG C
	57,176	61	>75% Grass cover, Good, HSG B
*	5,884	98	Impervious
	148,798	70	Weighted Average
	142,914		96.05% Pervious Area
	5,884		3.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
43.3	200	0.0050	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
1.5	240	0.0300	2.60		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
44.8	440	Total			

Summary for Subcatchment PRE1: PRE

Runoff = 7.28 cfs @ 12.52 hrs, Volume= 1.030 af, Depth= 1.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	193,524	61	>75% Grass cover, Good, HSG B
	10,319	74	>75% Grass cover, Good, HSG C
*	18,133	98	Impervious
	56,062	61	Pasture/grassland/range, Good, HSG B
*	3,311	88	Dirt Path, HSG C
	281,349	64	Weighted Average
	263,216		93.55% Pervious Area
	18,133		6.45% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.2	96	0.0100	0.09		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
0.5	22	0.0100	0.77		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 3.20"
8.3	82	0.0520	0.16		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
2.6	182	0.0280	1.17		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
3.9	484	0.0230	2.06	10.28	**Trap/Vee/Rect Channel Flow,** Bot.W=2.00' D=1.00' Z= 3.0 '/' Top.W=8.00' n= 0.078
1.8	260	0.0300	2.39	9.58	**Trap/Vee/Rect Channel Flow,** Bot.W=2.00' D=1.00' Z= 2.0 '/' Top.W=6.00' n= 0.078 Riprap, 12-inch
35.3	1,126	Total			

Summary for Subcatchment PRE2: PRE2

Runoff = 4.60 cfs @ 12.63 hrs, Volume= 0.712 af, Depth= 2.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs
Type III 24-hr 25-year Rainfall=5.50"

	Area (sf)	CN	Description
	76,789	74	>75% Grass cover, Good, HSG C
	57,372	61	>75% Grass cover, Good, HSG B
*	14,637	98	Impervious
	148,798	71	Weighted Average
	134,161		90.16% Pervious Area
	14,637		9.84% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
43.3	200	0.0050	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
1.5	240	0.0300	2.60		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
44.8	440	Total			

Summary for Pond 2P: Subsurface

Inflow Area = 1.297 ac, 43.82% Impervious, Inflow Depth = 3.05" for 25-year event
Inflow = 3.31 cfs @ 12.26 hrs, Volume= 0.329 af
Outflow = 0.57 cfs @ 13.03 hrs, Volume= 0.329 af, Atten= 83%, Lag= 46.4 min
Primary = 0.57 cfs @ 13.03 hrs, Volume= 0.329 af

Routing by Sim-Route method, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs

Peak Elev= 271.53' @ 13.03 hrs Surf.Area= 3,584 sf Storage= 6,274 cf
Flood Elev= 275.00' Surf.Area= 3,584 sf Storage= 7,746 cf

Plug-Flow detention time= 151.4 min calculated for 0.329 af (100% of inflow)
Center-of-Mass det. time= 150.5 min (987.6 - 837.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	269.50'	0 cf	**32.00'W x 112.00'L x 3.17'H Field A** 11,349 cf Overall - 11,349 cf Embedded = 0 cf x 40.0% Voids
#2A	269.50'	7,746 cf	**retain_it retain_it 2.5'** x 56 Inside #1 Inside= 84.0"W x 30.0"H => 17.56 sf x 8.00'L = 140.4 cf Outside= 96.0"W x 38.0"H => 25.33 sf x 8.00'L = 202.7 cf 4 Rows adjusted for 118.8 cf perimeter wall
		7,746 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	269.50'	**12.0" Round Culvert** L= 40.0' Ke= 0.500 Inlet / Outlet Invert= 269.50' / 269.00' S= 0.0125 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	269.50'	**4.0" Vert. Orifice/Grate** C= 0.600
#3	Device 1	271.70'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 3.5' Crest Height

Primary OutFlow Max=0.57 cfs @ 13.03 hrs HW=271.53' TW=0.00' (Dynamic Tailwater)
↑—**1=Culvert** (Passes 0.57 cfs of 4.67 cfs potential flow)
↑—**2=Orifice/Grate** (Orifice Controls 0.57 cfs @ 6.56 fps)
—**3=Sharp-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond CB: CDS

[58] Hint: Peaked 2.33' above defined flood level

Inflow Area = 1.297 ac, 43.82% Impervious, Inflow Depth = 3.05" for 25-year event
Inflow = 3.31 cfs @ 12.24 hrs, Volume= 0.329 af
Outflow = 3.31 cfs @ 12.26 hrs, Volume= 0.329 af, Atten= 0%, Lag= 1.2 min
Primary = 3.31 cfs @ 12.26 hrs, Volume= 0.329 af

Routing by Sim-Route method, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs
Peak Elev= 271.53' @ 13.03 hrs
Flood Elev= 269.20'

Device	Routing	Invert	Outlet Devices
#1	Primary	270.10'	**15.0" Round Culvert** L= 8.0' Ke= 0.500 Inlet / Outlet Invert= 270.10' / 270.00' S= 0.0125 '/' Cc= 0.900 n= 0.012, Flow Area= 1.23 sf

Primary OutFlow Max=3.31 cfs @ 12.26 hrs HW=271.20' TW=270.53' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 3.31 cfs @ 3.85 fps)

Summary for Pond DP1: DESIGN POINT 1

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 6.459 ac, 13.83% Impervious, Inflow Depth = 2.14" for 25-year event
Inflow = 6.34 cfs @ 12.53 hrs, Volume= 1.152 af
Primary = 6.34 cfs @ 12.55 hrs, Volume= 1.152 af, Atten= 0%, Lag= 1.2 min

Routing by Sim-Route method, Time Span= 2.00-72.00 hrs, dt= 0.02 hrs

Time span=2.00-72.00 hrs, dt=0.02 hrs, 3501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment POST 1A: POST 1A Runoff Area=224,833 sf 6.29% Impervious Runoff Depth=0.56"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=1.37 cfs 0.241 af

Subcatchment POST 1B: POST 1B Runoff Area=56,516 sf 43.82% Impervious Runoff Depth=1.21"
Flow Length=318' Tc=17.3 min CN=77 Runoff=1.27 cfs 0.131 af

Subcatchment POST2: POST2 Runoff Area=148,798 sf 3.95% Impervious Runoff Depth=0.83"
Flow Length=440' Tc=44.8 min CN=70 Runoff=1.38 cfs 0.236 af

Subcatchment PRE1: PRE Runoff Area=281,349 sf 6.45% Impervious Runoff Depth=0.56"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=1.71 cfs 0.301 af

Subcatchment PRE2: PRE2 Runoff Area=148,798 sf 9.84% Impervious Runoff Depth=0.88"
Flow Length=440' Tc=44.8 min CN=71 Runoff=1.48 cfs 0.250 af

Pond 2P: Subsurface Peak Elev=270.19' Storage=2,140 cf Inflow=1.27 cfs 0.131 af
Outflow=0.30 cfs 0.131 af

Pond CB: CDS Peak Elev=270.72' Inflow=1.27 cfs 0.131 af
15.0" Round Culvert n=0.012 L=8.0' S=0.0125 '/' Outflow=1.27 cfs 0.131 af

Pond DP1: DESIGN POINT 1 Inflow=1.66 cfs 0.371 af
Primary=1.66 cfs 0.371 af

Time span=2.00-72.00 hrs, dt=0.02 hrs, 3501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment POST 1A: POST 1A Runoff Area=224,833 sf 6.29% Impervious Runoff Depth=1.39"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=4.08 cfs 0.598 af

Subcatchment POST 1B: POST 1B Runoff Area=56,516 sf 43.82% Impervious Runoff Depth=2.37"
Flow Length=318' Tc=17.3 min CN=77 Runoff=2.57 cfs 0.257 af

Subcatchment POST2: POST2 Runoff Area=148,798 sf 3.95% Impervious Runoff Depth=1.82"
Flow Length=440' Tc=44.8 min CN=70 Runoff=3.28 cfs 0.517 af

Subcatchment PRE1: PRE Runoff Area=281,349 sf 6.45% Impervious Runoff Depth=1.39"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=5.10 cfs 0.748 af

Subcatchment PRE2: PRE2 Runoff Area=148,798 sf 9.84% Impervious Runoff Depth=1.89"
Flow Length=440' Tc=44.8 min CN=71 Runoff=3.43 cfs 0.539 af

Pond 2P: Subsurface Peak Elev=271.02' Storage=4,717 cf Inflow=2.57 cfs 0.257 af
Outflow=0.49 cfs 0.256 af

Pond CB: CDS Peak Elev=271.04' Inflow=2.57 cfs 0.257 af
15.0" Round Culvert n=0.012 L=8.0' S=0.0125 '/' Outflow=2.57 cfs 0.257 af

Pond DP1: DESIGN POINT 1 Inflow=4.53 cfs 0.854 af
Primary=4.53 cfs 0.854 af

Time span=2.00-72.00 hrs, dt=0.02 hrs, 3501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method

Subcatchment POST 1A: POST 1A Runoff Area=224,833 sf 6.29% Impervious Runoff Depth=2.93"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=9.13 cfs 1.258 af

Subcatchment POST 1B: POST 1B Runoff Area=56,516 sf 43.82% Impervious Runoff Depth=4.28"
Flow Length=318' Tc=17.3 min CN=77 Runoff=4.65 cfs 0.462 af

Subcatchment POST2: POST2 Runoff Area=148,798 sf 3.95% Impervious Runoff Depth=3.54"
Flow Length=440' Tc=44.8 min CN=70 Runoff=6.56 cfs 1.006 af

Subcatchment PRE1: PRE Runoff Area=281,349 sf 6.45% Impervious Runoff Depth=2.93"
Flow Length=1,126' Tc=35.3 min CN=64 Runoff=11.42 cfs 1.575 af

Subcatchment PRE2: PRE2 Runoff Area=148,798 sf 9.84% Impervious Runoff Depth=3.64"
Flow Length=440' Tc=44.8 min CN=71 Runoff=6.76 cfs 1.036 af

Pond 2P: Subsurface Peak Elev=271.96' Storage=7,616 cf Inflow=4.65 cfs 0.462 af
Outflow=2.34 cfs 0.462 af

Pond CB: CDS Peak Elev=272.12' Inflow=4.65 cfs 0.462 af
15.0" Round Culvert n=0.012 L=8.0' S=0.0125 '/' Outflow=4.65 cfs 0.462 af

Pond DP1: DESIGN POINT 1 Inflow=11.34 cfs 1.720 af
Primary=11.34 cfs 1.720 af

Appendix 4:
MISCELLANEOUS CALCULATIONS

CONTECH ENGINEERED SOLUTIONS

CDS TECHNOLOGIES

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

HILLSDALE COLLEGE
HILLSDALE, MI

Area	1.80 ac	Unit Site Designation	CDS
Weighted C	0.53	Rainfall Station #	36
t_c	15 min		
CDS Model	2015-4	CDS Treatment Capacity	**1.4 cfs**

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.08	34.3%	34.3%	0.08	0.08	32.0
0.16	21.4%	55.7%	0.15	0.15	19.2
0.24	13.3%	69.0%	0.23	0.23	11.5
0.32	8.7%	77.7%	0.30	0.30	7.2
0.40	5.1%	82.8%	0.38	0.38	4.0
0.48	2.8%	85.7%	0.46	0.46	2.1
0.56	2.6%	88.3%	0.53	0.53	1.9
0.64	1.8%	90.1%	0.61	0.61	1.2
0.72	1.2%	91.3%	0.68	0.68	0.8
0.80	1.3%	92.7%	0.76	0.76	0.8
1.00	1.7%	94.4%	0.95	0.95	0.9
2.00	3.8%	98.2%	1.90	1.40	0.8
3.00	1.1%	99.3%	2.85	1.40	0.2
4.00	0.7%	100.0%	3.80	1.40	0.1
0.00	0.0%	100.0%	0.00	0.00	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
0.00	0.0%	100.0%	0.00	0.00	0.0
					82.7
				Removal Efficiency Adjustment[2] =	0.0%
				Predicted % Annual Rainfall Treated =	98.0%
				Predicted Net Annual Load Removal Efficiency =	**82.7%**

1 - Based on 14 years of 15-minute data from NCDC station 4488, Mansfield Hollow Lake, Tolland County, CT
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

Project: Hillsdale College
Location: Somers, CT
Prepared For: JR Russo

Purpose: To calculate the first flush runoff flow rate (WQF) over a given site area. In this situation the WQV to be analyzed is the runoff produced by the first 1" of rainfall.

Reference: United States Department of Agriculture Natural Resources Conservation Service TR-55 Manual

Given:

Structure Name	A (acres)	A ($miles^2$)	Runoff Coefficient	Percent Imp. (%)*	t_c (min)	t_c (hr)
CDS	1.80	0.00281	0.53	38.00	15.0	0.250

* Assumes runoff coefficient of 0.3 for pervious areas and 0.9 for impervious areas.

Procedure: The Water Quality Flow (WQF) is calculated using the Water Quality Volume (WQV). This WQV, converted to watershed inches, is substituted for the runoff depth (Q) in the Natural Resources Conservation Service (formerly Soil Conservation Service), TR-55 Graphical Peak Discharge Method.

1. Compute WQV in watershed inches using the following equation:

$$WQV = P * R$$

where: WQV = water quality volume (watershed inches)
P = design precipitation (inches) = (1" for water quality storm)
R = volumetric runoff coefficient = 0.05 + 0.009(I)
I = percent impervious cover

Structure Name	Percent Imp. (%)	R	P (in)	WQV (in)	WQV (ac-ft)
CDS	38.00	0.392	1.0	0.392	0.0588

2. Compute the NRCS Runoff Curve Number (CN) using the following equation, or graphically using Figure 2-1 from TR-55 (USDA, 1986):

$$CN = 1000 / [10+5P+10Q-10(Q^2+1.25QP)^{1/2}]$$

where: CN = Runoff Curve Number
P = design precipitation (inches) = (1" for water quality storm)
Q = runoff depth (watershed inches)

Structure Name	Q (in)	CN
CDS	0.392	91.77

3. Using computed CN, read initial abstraction (I_a) from Table 4-1 in Chapter 4 of TR-55; compute I_a/P, interpolating when appropriate.

Structure Name	I_a (in)	I_a/P
CDS	0.179	0.179

4. Compute the time of concentration (t_c) in hours and the drainage area in square miles.

Structure Name	t_c (hr)	A (miles^2)
CDS	0.250	0.00281

5. Read the unit peak discharge (q_u) from Exhibit 4-III in Chapter 4 of TR-55 for appropriate t_c for type III rainfall distribution.

Structure Name	t_c (hr)	I_a/P	q_u (csm/in)
CDS	0.250	0.179426536	480

6. Substituting WQV (watershed inches) for runoff depth (Q), compute the water quality flow (WQF) from the following equation:

$$\mathbf{WQF = (q_u)*(A)*(Q)}$$

where: WQF = water quality flow (cfs)
q_u = unit peak discharge (cfs/mi^2/inch)
A = drainage area (mi^2)
Q = runoff depth (watershed inches)

Structure Name	q_u (csm/in)	A (miles^2)	Q (in)	WQF (cfs)
CDS	480	0.00281	0.392	0.53