STORMWATER MANAGEMENT REPORT

FOR

SUTTON DRIVE-IN

SITE PLAN REVIEW/SPECIAL PERMIT

100 WORCESTER-PROVIDENCE TURNPIKE, SUTTON, MA

DECEMBER 14, 2023

Applicant:

Eastland Partners, Inc.
997 Millbury Street
Worcester, MA 01607

Prepared By:

TURNING POINT
ENGINEERING
CIVIL SITE DESIGN

P.O. BOX 757
SUTTON, MA 01590

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PART 1 – SUMMARY

1.0 PROJECT DESCRIPTION

The project locus is identified as assessor map 10, parcel 18 totaling approximately 9.41 acres and is located at 100 Worcester-Providence Turnpike, also known as the Sutton Drive-In site, in the Town of Sutton. The property consists of previously developed areas that once was the site of a drive-in movie theatre with associated driveways and large parking areas. The site is being proposed to be redeveloped.

The project proponent intends to construct and operate a 28,000 s.f. building for the service and repair of tractor trailers. The building will consist of service bays for the repair of tractor trailers, warehouse for the storage of parts, and office for the business operation, with associated parking, loading docks, and storage of trailers.

The subject parcel falls within the Groundwater Protection District. There are no know areas of critical environmental concerns (ACEC's), NHESP Estimated or Priority Habitats, or Activity and Use Limitation areas (AUL). The subject site has a wetland resource area associated with a pond to the southeast of the site with associated buffer zones. There is also a perennial stream that flows from the existing pond to the culvert that flows under Route 146.

2.0 BACKGROUND DATA

Soils explorations will be performed on the property. The U.S. Natural Resources Conservation Service (NRCS), formerly SCS Soil Survey Maps indicate that soils with hydrologic soil group classifications B, C and D are present on the site, see Part III of this report.

3.0 COMPLIANCE WITH STORMWATER STANDARDS

3.1 Untreated Stormwater (Standard 1)

The project is designed so that new stormwater conveyances (outfalls/ discharges) do not discharge untreated stormwater into, or cause erosion to, wetlands.

Standard #1 is met.

3.2 Post-Development Peak Rates (Standard 2)

Hydrologic calculations were performed to determine the rate of runoff for the 2, 10, 25 and 100-year storm events under pre-development (present) conditions. This value was established as the future (post-development) maximum allowable rate. Unmitigated post-development rates were then computed in a similar manner. It is the intent of the stormwater management system to minimize impacts to drainage patterns of downstream property and wetlands while simultaneously providing water quality treatment to runoff prior to its release from the site or discharge to wetlands.

The U.S.D.A. Soil Conservation Service (SCS) Technical Release 55 (TR-55), 1986, was used as the procedure for estimating runoff. A SCS TR-20-based computer program, "HydroCAD," was used for estimating peak discharges. TR-55 is a generally accepted model for use on small sites that begins with a rainfall amount uniformly imposed on the watershed over a specified time distribution. Mass rainfall is converted to mass runoff by using a runoff curve number (CN). CN is based on soils, ground cover, impervious areas, interception and surface storage. Runoff is then transformed into a hydrograph that depends on runoff travel time through segments of the watershed.

Development in a watershed changes its response to precipitation. The most common effects are reduced infiltration and decreased travel time, which result in significantly higher peak rates of runoff. The volume of runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, antecedent rainfall, and type of vegetative cover, impervious surfaces, and surface retention. Travel time is determined primarily by slope, flow length, depth of flow surfaces. Peak rates of discharge are based on the relationship of the above parameters as well as the total drainage area of the watershed, the location of the development in relation to the total drainage area, and the effect of any flood control works or other manmade storage. Peak rates of discharge are also influenced by the distribution of rainfall within a given storm event.

Stormwater management computations for the project site were performed using SCS-based HydroCAD for existing and proposed conditions, curve numbers, time of concentration, and unit hydrograph computations. The following were considered as part of runoff calculations.

Since urban areas are seldom completely covered by impervious structure, soils and soil properties are an important factor in estimating the total volume of direct runoff. The infiltration and percolation rates of soils indicate their potential to absorb rainfall and thereby reduce the amount of direct runoff. Soils having a high infiltration rate (sands or gravels) have a low runoff potential, and soils having a low infiltration rate (clays) have a high runoff potential. Urbanization on soils with a high infiltration rate increases the volume of runoff and peak discharge more than urbanization on soils with a low infiltration rate.

The type of surface cover and its hydrologic condition affects runoff volume through its influence on the infiltration rate of the soil. Unused cultivated land yields more runoff than forested land for a given soil type. Covering areas with impervious material reduces surface storage and infiltration and increases the volume of runoff.

Some rainfall is retained on the ground surface and by vegetation before runoff begins. Interception is rainfall that is caught by foliage, twigs, branches, leaves, etc. This rainfall is lost to evaporation and thus never reaches the ground surface. Increasing the vegetative cover increases the amount of interception.

Surface depression storage begins when precipitation exceeds infiltration. Overland flow starts when the surface depressions are full. The water in depression storage is not available as direct runoff.

Initial abstraction is the sum of interception, depression, storage, and infiltration before runoff begins. It occurs on all types of cover, from lawn in good condition to pavement. However, the amount of initial abstraction is less on pavement than on lawn.

Travel time (Tt) is the time it takes water to travel from one location to another in a watershed. Tt is a component of time of concentration (Tc) that is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. Tc is computed by summing all the travel time for consecutive components of the drainage conveyance system.

Tc influences the shape and peak of the runoff hydrograph. Urbanization usually decreases Tc thereby increasing the peak discharge.
Development can change the effective slope of a watershed if flow paths are altered by channeling and by changing the surface grading for building lots, roads and ditches. The slopes of street gutters, roads and overland flow areas as well as stream channels are significant in determining travel times through urban watersheds.

Flow length may be reduced if natural meandering streams are changed to straight channels. It may be increased if overland flows are diverted through ditches, storm drains, or street gutters to larger collections systems.

Surface roughness is also a consideration. Flow velocity normally increases significantly when the flow path is changed from flow over rough surfaces of woodland, grassland and natural channels to sheet flow over smooth surfaces of parking lots, storm drains, gutters and lined channels.

3.2.1 Existing Conditions

Under the pre-development scenario, the watershed has been identified as one (1) subcatchment (SC) areas outlining runoff to a single analysis point referenced above, as shown on the plan entitled "PRE-DEVELOPMENT DRAINAGE MAP", included within the attached Maps. As shown on the referenced plan, the analysis point is to the same wetland system to ensure there was not an increase in peak rate runoff at the wetland line.

3.2.2 Proposed Conditions

The project proposes one (1) infiltration basin with a sediment forebay to accommodate stormwater runoff and provide recharge and water quality. A number of Best Management Practices (BMP's) have been proposed, including deep sump catch basins, and a sediment forebay and infiltration basin.
Under the post-development scenario, the site has been divided into four (4) drainage subcatchments, shown on the plan entitled "POST-DEVELOPMENT DRAINAGE MAP", included within Part II – Pre & Post Construction Computations. There is no increase in

contributing watershed area due to the development and peak runoff rates and volumes are mitigated through the construction of the proposed stormwater management system.

Post-development peak rates were determined and routed through infiltration basins with the resulting hydrographs added to the hydrographs for the overland areas. Based upon these analyses, the peak rates of runoff for the 2, 10, 25 and 100-year storm events are as follows:

Table 3.2.2.1 Stormwater Peak Rate Summary				
PEAK DISCHARGE RATE OF FLOW OFF-SITE				
Pre-Development (cfs)				
Analysis Point	2-YR	10-YR	25-YR	100-YR
AP 1	18.4	36.8	51.9	83.5
Post-Development (cfs)				
Analysis Point	2-YR	10-YR	25-YR	100-YR
AP 1	17.7	33.5	45.6	69.6
Pre-Development vs. Developed (cfs)				
Analysis Point	2-YR	10-YR	25-YR	100-YR
AP 1	-0.7	-3.3	-6.3	-13.9

Standard #2 is met.

3.3 Recharge to Groundwater (Standard 3)

Although runoff volumes will not increase after construction; recharge shall be provided. Therefore, stormwater runoff volume to be recharged to groundwater should be determined using the existing site (pre-development) soil conditions and the annual recharge from the post-development site should approximate the annual recharge from the pre-development or existing site, based on soil types.

Hydrologic Soil Group	Volume to Recharge (x Total Impervious Area)
A	0.60 inches of runoff
B	0.35 inches of runoff
C	0.25 inches of runoff
D	0.10 inches of runoff

Required Recharge Volume
0.60 inches runoff x total impervious area = Recharge Volume, "A" soil
0.35 inches runoff x total impervious area = Recharge Volume, "B" soil
0.25 inches runoff x total impervious area = Recharge Volume, "C" soil
0.10 inches runoff x total impervious area = Recharge Volume, "D" soil

Recharge Volume Required
0.60 inches x (1ft. /12in.) x (0) sq. ft. = 0 cubic feet
0.35 inches x (1ft. /12in.) x (101,407) sq. ft. = 2,958 cubic feet
0.25 inches x (1ft. /12in.) x (69,932) sq. ft. = 1,457 cubic feet
0.15 inches x (1ft. /12in.) x (16,210) sq. ft. = 203 cubic feet

Total Volume Required for Recharge = <u>4,618 cubic feet</u>

<u>Recharge Volume Provided</u>
Infiltration Basin 1 = *2,961 cu. ft. (volume below lowest outlet)

***Due to portions of the site lying within C and D soils with poor infiltration characteristics the stormwater management recharge system has been designed to the maximum extent practicable. The required recharge volume for the proposed impervious area within the mapped B soils has been met. The proposed stormwater system design is an improvement over the existing previously developed site which contains no on-site recharge.**

<u>Drawdown Time</u>
To determine whether an infiltration BMP will drain within 72 hours, the following formula must be used;

$$Time_{drawdown} = \frac{Rv}{(K)(Bottom\ Area)}$$

Where:
Rv = Storage Volume
K = Saturated Hydraulic Conductivity For "Static" and "Simple Dynamic" Methods, use Rawls Rate (see Table 2.3.3). For "Dynamic Field" Method, use 50% of the in-situ saturated hydraulic conductivity.
Bottom Area = Bottom Area of Recharge Structure

Basin Storage Volume / ((Infiltration Rate / 12) x Basin Bottom Area))

Infiltration Basin 1:
5,385 c.f. / (0.27 in/hr)(1 ft/12 in)(2,862 s.f.) = 46.0 hours

Standard #3 is met.

3.4 Removal of 80% TSS (Standard 4)

The proposed stormwater management system design calls for 4' deep sump catch basins to collect runoff from the roadway. Stormwater runoff from pavement areas will then be conveyed by a closed pipe system to a proprietary separator to a sediment forebay followed by infiltration basins. Calculations for removal rates for all paved runoff are below. These calculations are shown on the attached TSS Calculation Worksheets.

Deep Sump Catch Basins	25%
Infiltration Basin w/ Sediment Forebay	80%
HydroWorks HydroDome	80%

Water Quality
Vwq = (Dwq ÷ 12inches/foot) (Aimp)
Where:
Vwq = Required Water Quality Volume (cubic feet)
Dwq = Water Quality Depth – 1.0 inches
Aimp = Impervious Area (s.f.)

Vwq Required
Infiltration Basin 1
1.0 inch x (1ft. /12in.) x (158,761) sq. ft. = 13,230 cubic feet

Water Quality Volume Provided
The water quality volume has been provided in the proprietary separator units (HD1, HD2 and HD3) and HydroWorks sizing calculations have been provided within this report.

Standard #4 is met.

3.5 Land Uses with Higher Potential (Standard 5)

This project does contain "fleet storage" and the stormwater system has been designed accordingly.

Standard #5 is met.

3.6 Critical Areas (Standard 6 – Water Quality Treatments)

The subject property falls within the Zone II Protection Area of a public water supply and the Grafton Water Supply Protection Overlay. Water Quality Treatment have been provided in accordance with Massachusetts Stormwater Standards.

Standard #6 is met.

3.7 Redevelopment (Standard 7)

Redevelopment projects are those that involve development, rehabilitation or expansion on previously developed sites provided the redevelopment results in no net increase in impervious area. Furthermore, components of redevelopment project, which include development of previously undeveloped sites, do not fall under Standard 7. In addition, redevelopment of previously developed sites must meet the Stormwater Management Standards to the maximum extent practicable. However, if it is not practicable to meet all the Standards, new (retrofitted or expanded) stormwater management systems must be designed to improve existing conditions.

The project site was formerly used as the Sutton Drive-In and contains approximately 4.7 acres of existing pavement and buildings. A portion of the previously disturbed area will be restored with a number of proposed plantings and green space.

Standard #7 is met.

3.8 Erosion and Sedimentation Controls (Standard 8)

A separate Operation & Maintenance Plan has been provided.

Standard #8 is met.

3.9 Operation and Maintenance Plan (Standard 9)

A separate Operation & Maintenance Plan has been provided.

Standard #9 is met.

3.10 Illicit Discharges (Standard 10)

See Illicit Discharge statement on following page.

Standard #10 is met.

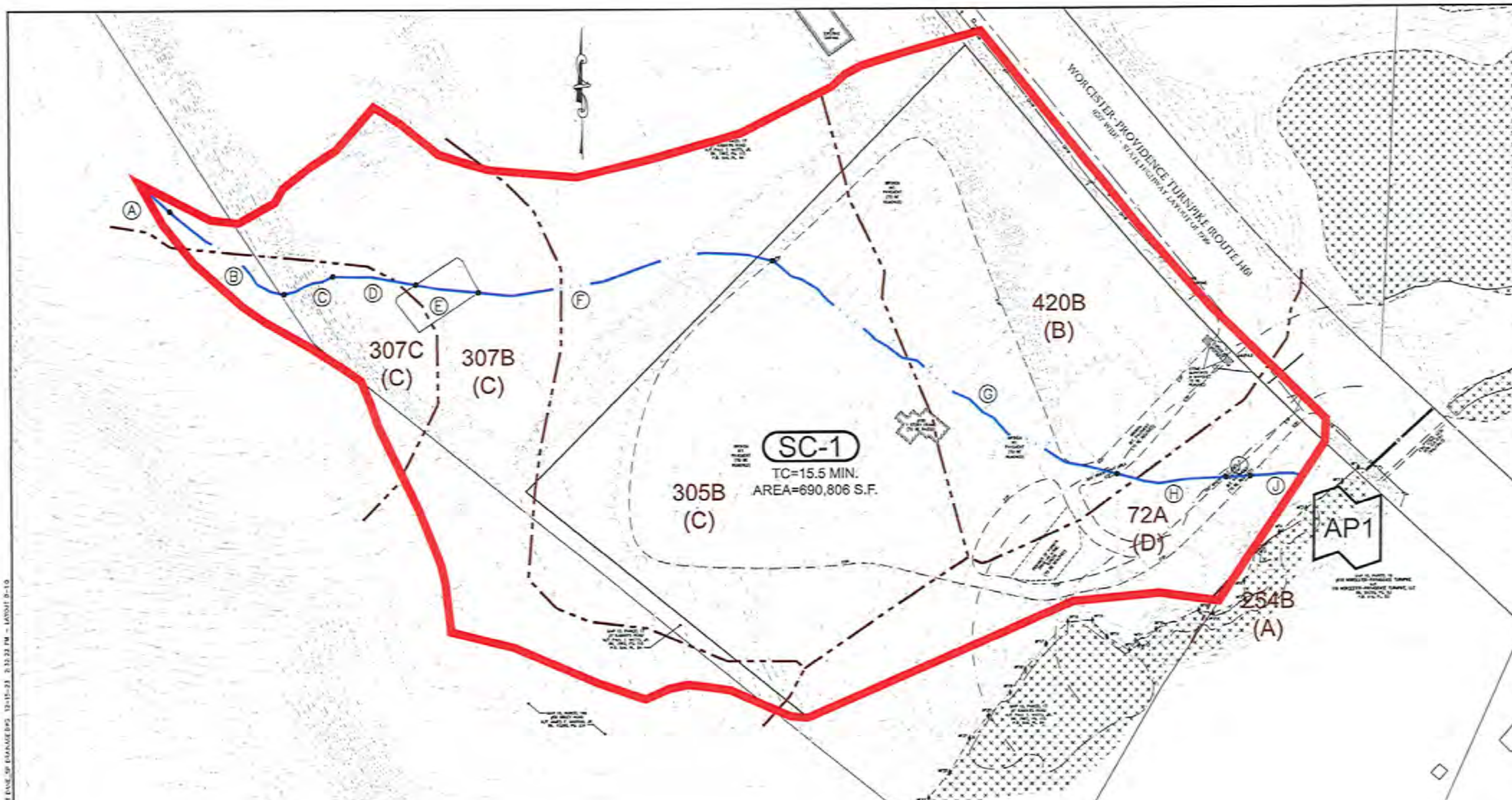
Attachment
Illicit Discharge Compliance Statement

It is the intent of the Applicant, Eastland Partners, Inc., to control illicit disposal into the storm drainage system. There will be no connection to the storm water system to inadvertently direct other types of liquids, chemicals or solids into the storm drainage system. The Applicant will also promote a clean Green Environment by mitigating spills onto pavements; oils, soda, chemicals, pet waste, debris and litter.

Respectfully Acknowledged,

Eastland Partners, Inc.

PART II – PRE & POST-CONSTRUCTION COMPUTATIONS



LEGEND

SUBCATCHMENT LIMIT

SC-1 SUBCATCHMENT LABEL

TIME OF CONCENTRATION

AP1 DRAINAGE ANALYSIS POINT

MAPPED SOIL BOUNDARY

254B (A) SOIL MAP UNIT & HYDROLOGIC SOIL GROUP LISTING

TURNING POINT ENGINEERING
CIVIL SITE DESIGN
P.O. Box 757 - Sutton, MA 01590

PROJECT NAME

NORTHEAST GREAT DANE
#100 WORCESTER-PROVIDENCE TURNPIKE
SUTTON, MASSACHUSETTS

SUTTON MOTOR-IN TRUST
ONE MERCANTILE STREET, SUITE 540
WORCESTER, MA 01608

PREPARED FOR

Eastland

Eastland Partners, Inc.

REVISIONS		
REV.	DATE	DESCRIPTION

PROJECT NO.	TPE-1126
DESIGNED BY	IB, WCN
CHECKED BY	SO
DATE	12/7/23
CAD FILE	H:\1126_GREAT DANE_SP Drawings
PLAN NO.	XXX

GRAPHIC SCALE

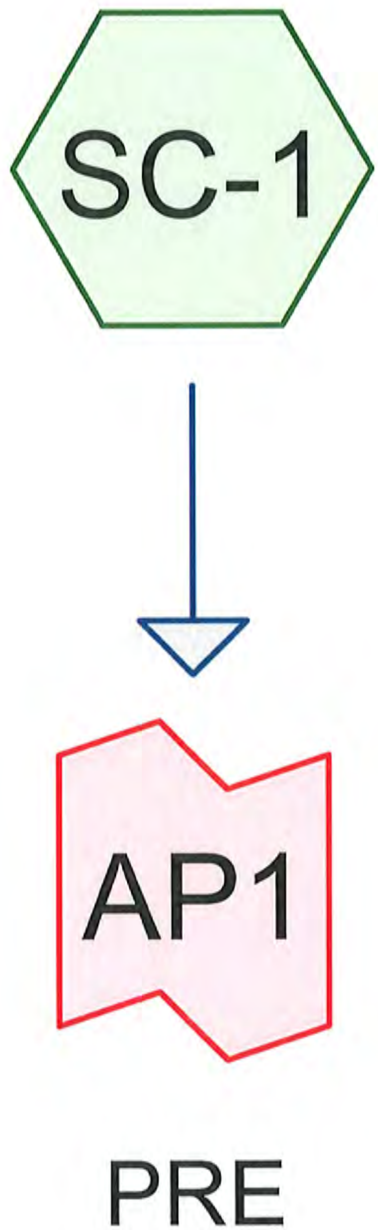
(IN FEET)
1 inch = 60 feet

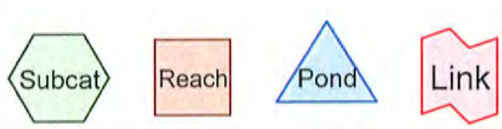
SHEET TITLE

PRE-DEVELOPMENT DRAINAGE MAP

SHEET NO.

D-1.0





Routing Diagram for Great Dane
Prepared by Turning Point Engineering, Printed 12/18/2023
HydroCAD® 10.00-20 s/n 10079 © 2017 HydroCAD Software Solutions LLC

Area Listing (selected nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
45,890	61	>75% Grass cover, Good, HSG B (SC-1)
103,817	74	>75% Grass cover, Good, HSG C (SC-1)
24,992	80	>75% Grass cover, Good, HSG D (SC-1)
45,115	87	Dirt roads, HSG C (SC-1)
72,182	98	Paved parking, HSG B (SC-1)
126,586	98	Paved parking, HSG C (SC-1)
15,474	98	Paved parking, HSG D (SC-1)
860	98	Roofs, HSG B (SC-1)
1,391	98	Roofs, HSG C (SC-1)
203	30	Woods, Good, HSG A (SC-1)
65,192	55	Woods, Good, HSG B (SC-1)
152,956	70	Woods, Good, HSG C (SC-1)
36,149	77	Woods, Good, HSG D (SC-1)
690,807	**79**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
203	HSG A	SC-1
184,124	HSG B	SC-1
429,865	HSG C	SC-1
76,615	HSG D	SC-1
0	Other	
690,807		**TOTAL AREA**

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC-1: Runoff Area=690,807 sf 31.34% Impervious Runoff Depth=1.35"
Flow Length=1,558' Tc=15.5 min CN=79 Runoff=18.37 cfs 77,817 cf

Link AP1: PRE Inflow=18.37 cfs 77,817 cf
Primary=18.37 cfs 77,817 cf

Total Runoff Area = 690,807 sf Runoff Volume = 77,817 cf Average Runoff Depth = 1.35"
68.66% Pervious = 474,314 sf 31.34% Impervious = 216,493 sf

Summary for Subcatchment SC-1:

Runoff = 18.37 cfs @ 12.22 hrs, Volume= 77,817 cf, Depth= 1.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.22"

Area (sf)	CN	Description
203	30	Woods, Good, HSG A
65,192	55	Woods, Good, HSG B
72,182	98	Paved parking, HSG B
45,890	61	>75% Grass cover, Good, HSG B
860	98	Roofs, HSG B
152,956	70	Woods, Good, HSG C
1,391	98	Roofs, HSG C
126,586	98	Paved parking, HSG C
103,817	74	>75% Grass cover, Good, HSG C
45,115	87	Dirt roads, HSG C
36,149	77	Woods, Good, HSG D
15,474	98	Paved parking, HSG D
24,992	80	>75% Grass cover, Good, HSG D
690,807	79	Weighted Average
474,314		68.66% Pervious Area
216,493		31.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
2.0	364	0.0359	3.05		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.4	502	0.0901	6.09		**Shallow Concentrated Flow, SEGMENT G** Paved Kv= 20.3 fps
0.6	134	0.0583	3.89		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.2	29	0.0157	2.54		**Shallow Concentrated Flow, SEGMENT I** Paved Kv= 20.3 fps
0.2	64	0.0720	4.32		**Shallow Concentrated Flow, SEGMENT J** Unpaved Kv= 16.1 fps
15.5	1,558	Total			

Summary for Link AP1: PRE

Inflow Area =	690,807 sf,	31.34% Impervious,	Inflow Depth = 1.35"	for 2-Year event
Inflow =	18.37 cfs @	12.22 hrs, Volume=	77,817 cf	
Primary =	18.37 cfs @	12.22 hrs, Volume=	77,817 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC-1: Runoff Area=690,807 sf 31.34% Impervious Runoff Depth=2.66"
Flow Length=1,558' Tc=15.5 min CN=79 Runoff=36.77 cfs 152,892 cf

Link AP1: PRE Inflow=36.77 cfs 152,892 cf
Primary=36.77 cfs 152,892 cf

Total Runoff Area = 690,807 sf Runoff Volume = 152,892 cf Average Runoff Depth = 2.66"
68.66% Pervious = 474,314 sf 31.34% Impervious = 216,493 sf

Summary for Subcatchment SC-1:

Runoff = 36.77 cfs @ 12.22 hrs, Volume= 152,892 cf, Depth= 2.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
203	30	Woods, Good, HSG A
65,192	55	Woods, Good, HSG B
72,182	98	Paved parking, HSG B
45,890	61	>75% Grass cover, Good, HSG B
860	98	Roofs, HSG B
152,956	70	Woods, Good, HSG C
1,391	98	Roofs, HSG C
126,586	98	Paved parking, HSG C
103,817	74	>75% Grass cover, Good, HSG C
45,115	87	Dirt roads, HSG C
36,149	77	Woods, Good, HSG D
15,474	98	Paved parking, HSG D
24,992	80	>75% Grass cover, Good, HSG D
690,807	79	Weighted Average
474,314		68.66% Pervious Area
216,493		31.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
2.0	364	0.0359	3.05		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.4	502	0.0901	6.09		**Shallow Concentrated Flow, SEGMENT G** Paved Kv= 20.3 fps
0.6	134	0.0583	3.89		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.2	29	0.0157	2.54		**Shallow Concentrated Flow, SEGMENT I** Paved Kv= 20.3 fps
0.2	64	0.0720	4.32		**Shallow Concentrated Flow, SEGMENT J** Unpaved Kv= 16.1 fps
15.5	1,558	Total			

Summary for Link AP1: PRE

Inflow Area =	690,807 sf, 31.34% Impervious,	Inflow Depth = 2.66"	for 10-Year event	
Inflow =	36.77 cfs @ 12.22 hrs,	Volume=	152,892 cf	
Primary =	36.77 cfs @ 12.22 hrs,	Volume=	152,892 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC-1: Runoff Area=690,807 sf 31.34% Impervious Runoff Depth=3.75"
Flow Length=1,558' Tc=15.5 min CN=79 Runoff=51.88 cfs 215,944 cf

Link AP1: PRE Inflow=51.88 cfs 215,944 cf
Primary=51.88 cfs 215,944 cf

Total Runoff Area = 690,807 sf Runoff Volume = 215,944 cf Average Runoff Depth = 3.75"
68.66% Pervious = 474,314 sf 31.34% Impervious = 216,493 sf

Summary for Subcatchment SC-1:

Runoff = 51.88 cfs @ 12.21 hrs, Volume= 215,944 cf, Depth= 3.75"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.08"

Area (sf)	CN	Description
203	30	Woods, Good, HSG A
65,192	55	Woods, Good, HSG B
72,182	98	Paved parking, HSG B
45,890	61	>75% Grass cover, Good, HSG B
860	98	Roofs, HSG B
152,956	70	Woods, Good, HSG C
1,391	98	Roofs, HSG C
126,586	98	Paved parking, HSG C
103,817	74	>75% Grass cover, Good, HSG C
45,115	87	Dirt roads, HSG C
36,149	77	Woods, Good, HSG D
15,474	98	Paved parking, HSG D
24,992	80	>75% Grass cover, Good, HSG D
690,807	79	Weighted Average
474,314		68.66% Pervious Area
216,493		31.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
2.0	364	0.0359	3.05		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.4	502	0.0901	6.09		**Shallow Concentrated Flow, SEGMENT G** Paved Kv= 20.3 fps
0.6	134	0.0583	3.89		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.2	29	0.0157	2.54		**Shallow Concentrated Flow, SEGMENT I** Paved Kv= 20.3 fps
0.2	64	0.0720	4.32		**Shallow Concentrated Flow, SEGMENT J** Unpaved Kv= 16.1 fps
15.5	1,558	Total			

Summary for Link AP1: PRE

Inflow Area =	690,807 sf,	31.34% Impervious,	Inflow Depth = 3.75"	for 25-Year event	
Inflow =	51.88 cfs @	12.21 hrs,	Volume=	215,944 cf	
Primary =	51.88 cfs @	12.21 hrs,	Volume=	215,944 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment SC-1: Runoff Area=690,807 sf 31.34% Impervious Runoff Depth=6.11"
Flow Length=1,558' Tc=15.5 min CN=79 Runoff=83.46 cfs 351,531 cf

Link AP1: PRE Inflow=83.46 cfs 351,531 cf
Primary=83.46 cfs 351,531 cf

Total Runoff Area = 690,807 sf Runoff Volume = 351,531 cf Average Runoff Depth = 6.11"
68.66% Pervious = 474,314 sf 31.34% Impervious = 216,493 sf

Summary for Subcatchment SC-1:

Runoff = 83.46 cfs @ 12.21 hrs, Volume= 351,531 cf, Depth= 6.11"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.64"

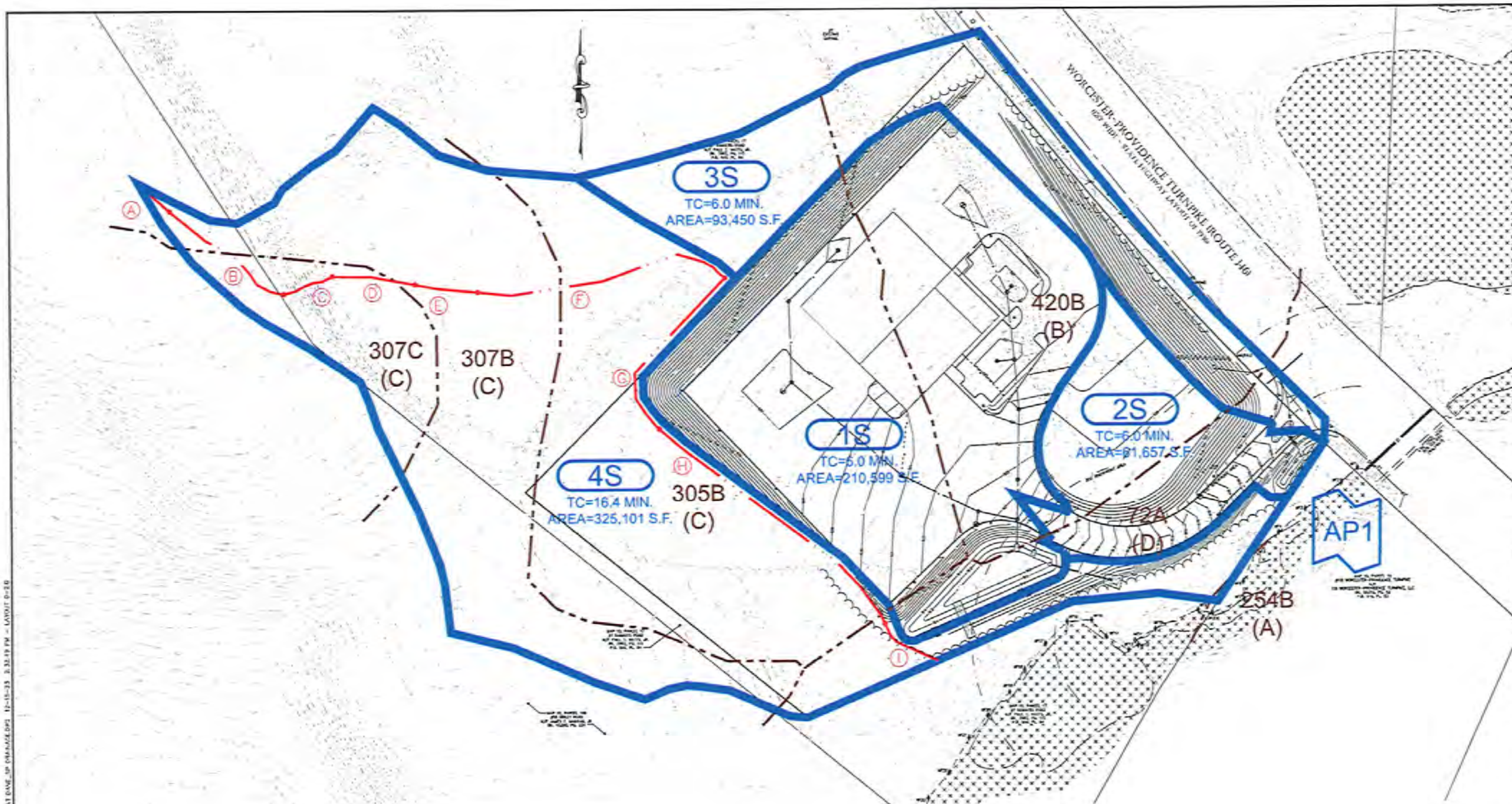
Area (sf)	CN	Description
203	30	Woods, Good, HSG A
65,192	55	Woods, Good, HSG B
72,182	98	Paved parking, HSG B
45,890	61	>75% Grass cover, Good, HSG B
860	98	Roofs, HSG B
152,956	70	Woods, Good, HSG C
1,391	98	Roofs, HSG C
126,586	98	Paved parking, HSG C
103,817	74	>75% Grass cover, Good, HSG C
45,115	87	Dirt roads, HSG C
36,149	77	Woods, Good, HSG D
15,474	98	Paved parking, HSG D
24,992	80	>75% Grass cover, Good, HSG D
690,807	79	Weighted Average
474,314		68.66% Pervious Area
216,493		31.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
2.0	364	0.0359	3.05		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.4	502	0.0901	6.09		**Shallow Concentrated Flow, SEGMENT G** Paved Kv= 20.3 fps
0.6	134	0.0583	3.89		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.2	29	0.0157	2.54		**Shallow Concentrated Flow, SEGMENT I** Paved Kv= 20.3 fps
0.2	64	0.0720	4.32		**Shallow Concentrated Flow, SEGMENT J** Unpaved Kv= 16.1 fps
15.5	1,558	Total			

Summary for Link AP1: PRE

Inflow Area =	690,807 sf,	31.34% Impervious,	Inflow Depth = 6.11"	for 100-Year event
Inflow =	83.46 cfs @	12.21 hrs, Volume=	351,531 cf	
Primary =	83.46 cfs @	12.21 hrs, Volume=	351,531 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs



LEGEND

(line)	SUBCATCHMENT LIMIT
1S	SUBCATCHMENT LABEL
(red dash-dot line)	TIME OF CONCENTRATION
AP1	DRAINAGE ANALYSIS POINT
(line)	MAPPED SOIL BOUNDARY
254B (A)	SOIL MAP UNIT & HYDROLOGIC SOIL GROUP LISTING

TURNING POINT ENGINEERING
CIVIL/SITE DESIGN
P.O. Box 959 • Milford, MA 01757

PROJECT NAME
NORTHEAST GREAT DANE
#100 WORCESTER-PROVIDENCE TURNPIKE
SUTTON, MASSACHUSETTS

SUTTON MOTOR-IN TRUST
ONE MERCANTILE STREET, SUITE 540
WORCESTER, MA 01608

PREPARED FOR
Eastland
Eastland Partners, Inc.
597 Millbury Street
Worcester, MA 01607

REVISIONS

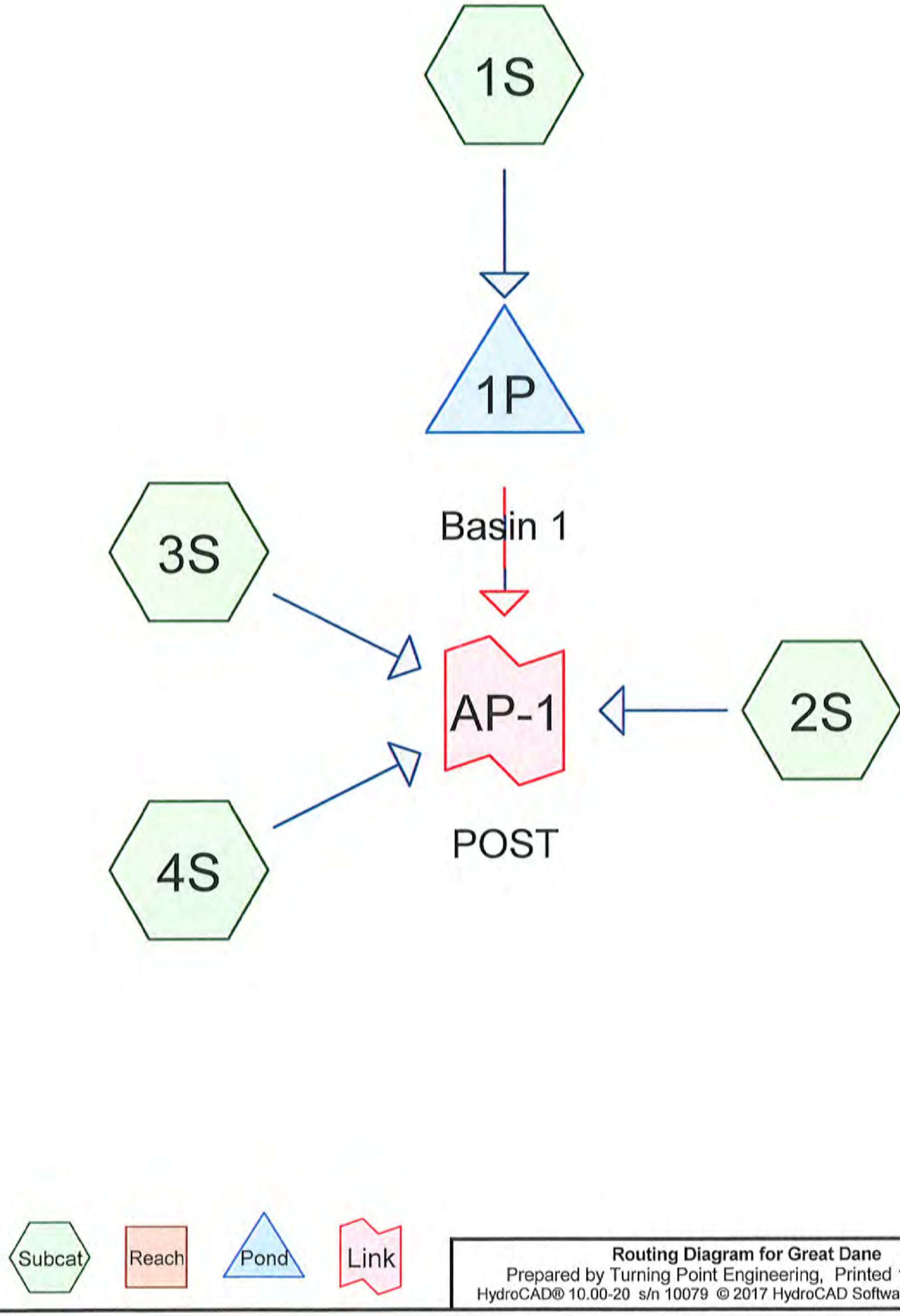
REV.	DATE	DESCRIPTION

PROJECT NO.	TPE-1126
DESIGNED BY	IB, WEN
CHECKED BY	SO
DATE	12/7/23
CAD FILE	H:\1126...GREAT DANE_SP Drainage
PLAN NO.	XXX

GRAPHIC SCALE
(IN FEET)
1 inch = 50 feet

SHEET TITLE
POST DEVELOPMENT DRAINAGE MAP

SHEET NO.
D-2.0



Routing Diagram for Great Dane
Prepared by Turning Point Engineering, Printed 12/18/2023

Area Listing (selected nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
59,651	61	>75% Grass cover, Good, HSG B (1S, 2S, 3S)
155,421	74	>75% Grass cover, Good, HSG C (1S, 3S, 4S)
47,014	80	>75% Grass cover, Good, HSG D (1S, 2S, 3S, 4S)
45,115	96	Gravel surface, HSG C (3S, 4S)
101,407	98	Paved parking, HSG B (1S, 2S, 3S)
69,932	98	Paved parking, HSG C (1S, 3S, 4S)
16,210	98	Paved parking, HSG D (1S, 2S, 3S)
16,427	98	Unconnected roofs, HSG B (1S)
12,373	98	Unconnected roofs, HSG C (1S)
203	30	Woods, Good, HSG A (4S)
6,639	55	Woods, Good, HSG B (3S)
147,023	70	Woods, Good, HSG C (3S, 4S)
13,391	77	Woods, Good, HSG D (4S)
690,806	**81**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
203	HSG A	4S
184,124	HSG B	1S, 2S, 3S
429,864	HSG C	1S, 3S, 4S
76,615	HSG D	1S, 2S, 3S, 4S
0	Other	
690,806		**TOTAL AREA**

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=210,598 sf 75.39% Impervious Runoff Depth=2.37"
Tc=6.0 min CN=92 Runoff=12.82 cfs 41,587 cf

Subcatchment 2S: Runoff Area=61,657 sf 73.02% Impervious Runoff Depth=2.37"
Tc=6.0 min CN=92 Runoff=3.75 cfs 12,175 cf

Subcatchment 3S: Runoff Area=93,450 sf 8.36% Impervious Runoff Depth=0.84"
Tc=6.0 min CN=70 Runoff=1.87 cfs 6,540 cf

Subcatchment 4S: Runoff Area=325,101 sf 1.46% Impervious Runoff Depth=1.17"
Flow Length=1,461' Tc=16.4 min CN=76 Runoff=7.12 cfs 31,588 cf

Pond 1P: Basin 1 Peak Elev=512.69' Storage=11,394 cf Inflow=12.82 cfs 41,587 cf
Discarded=0.04 cfs 4,894 cf Primary=6.78 cfs 36,676 cf Secondary=0.00 cfs 0 cf Outflow=6.82 cfs 41,570 cf

Link AP-1: POST Inflow=17.15 cfs 86,978 cf
Primary=17.15 cfs 86,978 cf

Total Runoff Area = 690,806 sf Runoff Volume = 91,889 cf Average Runoff Depth = 1.60"
68.68% Pervious = 474,457 sf 31.32% Impervious = 216,349 sf

Summary for Subcatchment 1S:

Runoff = 12.82 cfs @ 12.09 hrs, Volume= 41,587 cf, Depth= 2.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.22"

Area (sf)	CN	Description
16,427	98	Unconnected roofs, HSG B
12,373	98	Unconnected roofs, HSG C
64,769	98	Paved parking, HSG B
65,170	98	Paved parking, HSG C
22	98	Paved parking, HSG D
13,907	61	>75% Grass cover, Good, HSG B
26,197	74	>75% Grass cover, Good, HSG C
11,733	80	>75% Grass cover, Good, HSG D
210,598	92	Weighted Average
51,837		24.61% Pervious Area
158,761		75.39% Impervious Area
28,800		18.14% Unconnected

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

Summary for Subcatchment 2S:

Runoff = 3.75 cfs @ 12.09 hrs, Volume= 12,175 cf, Depth= 2.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.22"

Area (sf)	CN	Description
31,315	98	Paved parking, HSG B
13,704	98	Paved parking, HSG D
2,149	61	>75% Grass cover, Good, HSG B
14,489	80	>75% Grass cover, Good, HSG D
61,657	92	Weighted Average
16,638		26.98% Pervious Area
45,019		73.02% Impervious Area

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

Summary for Subcatchment 3S:

Runoff = 1.87 cfs @ 12.10 hrs, Volume= 6,540 cf, Depth= 0.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.22"

Area (sf)	CN	Description
6,044	96	Gravel surface, HSG C
5,323	98	Paved parking, HSG B
1	98	Paved parking, HSG C
2,484	98	Paved parking, HSG D
43,595	61	>75% Grass cover, Good, HSG B
18,013	74	>75% Grass cover, Good, HSG C
2,457	80	>75% Grass cover, Good, HSG D
6,639	55	Woods, Good, HSG B
8,894	70	Woods, Good, HSG C
93,450	70	Weighted Average
85,642		91.64% Pervious Area
7,808		8.36% Impervious Area

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

Summary for Subcatchment 4S:

Runoff = 7.12 cfs @ 12.24 hrs, Volume= 31,588 cf, Depth= 1.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.22"

Area (sf)	CN	Description
39,071	96	Gravel surface, HSG C
4,761	98	Paved parking, HSG C
111,211	74	>75% Grass cover, Good, HSG C
18,335	80	>75% Grass cover, Good, HSG D
203	30	Woods, Good, HSG A
138,129	70	Woods, Good, HSG C
13,391	77	Woods, Good, HSG D
325,101	76	Weighted Average
320,340		98.54% Pervious Area
4,761		1.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
1.8	314	0.0330	2.92		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.9	236	0.0161	2.04		**Shallow Concentrated Flow, SEGMENT G** Unpaved Kv= 16.1 fps
1.2	364	0.0930	4.91		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.4	82	0.0556	3.80		**Shallow Concentrated Flow, SEGMENT I** Unpaved Kv= 16.1 fps
16.4	1,461	Total			

Summary for Pond 1P: Basin 1

Inflow Area = 210,598 sf, 75.39% Impervious, Inflow Depth = 2.37" for 2-Year event
Inflow = 12.82 cfs @ 12.09 hrs, Volume= 41,587 cf
Outflow = 6.82 cfs @ 12.23 hrs, Volume= 41,570 cf, Atten= 47%, Lag= 8.4 min
Discarded = 0.04 cfs @ 12.23 hrs, Volume= 4,894 cf
Primary = 6.78 cfs @ 12.23 hrs, Volume= 36,676 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 512.69' @ 12.23 hrs Surf.Area= 5,745 sf Storage= 11,394 cf

Plug-Flow detention time= 197.8 min calculated for 41,541 cf (100% of inflow)
Center-of-Mass det. time= 199.3 min (996.9 - 797.5)

Volume	Invert	Avail.Storage	Storage Description
#1	510.00'	37,555 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)
510.00	2,862	291.0	0	0	2,862
512.00	4,933	372.0	7,702	7,702	7,187
514.00	7,446	438.0	12,293	19,995	11,517
516.00	10,186	475.5	17,561	37,555	14,392

Device	Routing	Invert	Outlet Devices
#1	Secondary	515.00'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#2	Primary	507.00'	**24.0" Round Culvert** L= 75.8' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 507.00' / 505.00' S= 0.0264 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#3	Device 2	511.25'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 2	512.50'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#5	Device 2	510.90'	**6.0" Vert. Orifice/Grate** C= 0.600
#6	Device 2	515.00'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#7	Discarded	510.00'	**0.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.04 cfs @ 12.23 hrs HW=512.69' (Free Discharge)
└─**7=Exfiltration** (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=6.76 cfs @ 12.23 hrs HW=512.69' (Free Discharge)
└─**2=Culvert** (Passes 6.76 cfs of 32.75 cfs potential flow)
  ├─**3=Orifice/Grate** (Orifice Controls 5.31 cfs @ 4.87 fps)
  ├─**4=Orifice/Grate** (Orifice Controls 0.27 cfs @ 1.48 fps)
  ├─**5=Orifice/Grate** (Orifice Controls 1.17 cfs @ 5.97 fps)
  └─**6=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=510.00' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link AP-1: POST

Inflow Area = 690,806 sf, 31.32% Impervious, Inflow Depth = 1.51" for 2-Year event
Inflow = 17.15 cfs @ 12.20 hrs, Volume= 86,978 cf
Primary = 17.15 cfs @ 12.20 hrs, Volume= 86,978 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=210,598 sf 75.39% Impervious Runoff Depth=3.92"
Tc=6.0 min CN=92 Runoff=20.67 cfs 68,854 cf

Subcatchment 2S: Runoff Area=61,657 sf 73.02% Impervious Runoff Depth=3.92"
Tc=6.0 min CN=92 Runoff=6.05 cfs 20,159 cf

Subcatchment 3S: Runoff Area=93,450 sf 8.36% Impervious Runoff Depth=1.91"
Tc=6.0 min CN=70 Runoff=4.62 cfs 14,883 cf

Subcatchment 4S: Runoff Area=325,101 sf 1.46% Impervious Runoff Depth=2.40"
Flow Length=1,461' Tc=16.4 min CN=76 Runoff=15.16 cfs 64,916 cf

Pond 1P: Basin 1 Peak Elev=513.39' Storage=15,717 cf Inflow=20.67 cfs 68,854 cf
Discarded=0.04 cfs 5,127 cf Primary=11.93 cfs 63,708 cf Secondary=0.00 cfs 0 cf Outflow=11.97 cfs 68,835 cf

Link AP-1: POST Inflow=33.43 cfs 163,665 cf
Primary=33.43 cfs 163,665 cf

Total Runoff Area = 690,806 sf Runoff Volume = 168,812 cf Average Runoff Depth = 2.93"
68.68% Pervious = 474,457 sf 31.32% Impervious = 216,349 sf

Summary for Subcatchment 1S:

Runoff = 20.67 cfs @ 12.09 hrs, Volume= 68,854 cf, Depth= 3.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
16,427	98	Unconnected roofs, HSG B
12,373	98	Unconnected roofs, HSG C
64,769	98	Paved parking, HSG B
65,170	98	Paved parking, HSG C
22	98	Paved parking, HSG D
13,907	61	>75% Grass cover, Good, HSG B
26,197	74	>75% Grass cover, Good, HSG C
11,733	80	>75% Grass cover, Good, HSG D
210,598	92	Weighted Average
51,837		24.61% Pervious Area
158,761		75.39% Impervious Area
28,800		18.14% Unconnected

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

Summary for Subcatchment 2S:

Runoff = 6.05 cfs @ 12.09 hrs, Volume= 20,159 cf, Depth= 3.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
31,315	98	Paved parking, HSG B
13,704	98	Paved parking, HSG D
2,149	61	>75% Grass cover, Good, HSG B
14,489	80	>75% Grass cover, Good, HSG D
61,657	92	Weighted Average
16,638		26.98% Pervious Area
45,019		73.02% Impervious Area

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

Summary for Subcatchment 3S:

Runoff = 4.62 cfs @ 12.10 hrs, Volume= 14,883 cf, Depth= 1.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
6,044	96	Gravel surface, HSG C
5,323	98	Paved parking, HSG B
1	98	Paved parking, HSG C
2,484	98	Paved parking, HSG D
43,595	61	>75% Grass cover, Good, HSG B
18,013	74	>75% Grass cover, Good, HSG C
2,457	80	>75% Grass cover, Good, HSG D
6,639	55	Woods, Good, HSG B
8,894	70	Woods, Good, HSG C
93,450	70	Weighted Average
85,642		91.64% Pervious Area
7,808		8.36% Impervious Area

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

Summary for Subcatchment 4S:

Runoff = 15.16 cfs @ 12.23 hrs, Volume= 64,916 cf, Depth= 2.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.83"

Area (sf)	CN	Description
39,071	96	Gravel surface, HSG C
4,761	98	Paved parking, HSG C
111,211	74	>75% Grass cover, Good, HSG C
18,335	80	>75% Grass cover, Good, HSG D
203	30	Woods, Good, HSG A
138,129	70	Woods, Good, HSG C
13,391	77	Woods, Good, HSG D
325,101	76	Weighted Average
320,340		98.54% Pervious Area
4,761		1.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
1.8	314	0.0330	2.92		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.9	236	0.0161	2.04		**Shallow Concentrated Flow, SEGMENT G** Unpaved Kv= 16.1 fps
1.2	364	0.0930	4.91		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.4	82	0.0556	3.80		**Shallow Concentrated Flow, SEGMENT I** Unpaved Kv= 16.1 fps
16.4	1,461	Total			

Summary for Pond 1P: Basin 1

Inflow Area = 210,598 sf, 75.39% Impervious, Inflow Depth = 3.92" for 10-Year event
Inflow = 20.67 cfs @ 12.09 hrs, Volume= 68,854 cf
Outflow = 11.97 cfs @ 12.21 hrs, Volume= 68,835 cf, Atten= 42%, Lag= 7.4 min
Discarded = 0.04 cfs @ 12.21 hrs, Volume= 5,127 cf
Primary = 11.93 cfs @ 12.21 hrs, Volume= 63,708 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 513.39' @ 12.21 hrs Surf.Area= 6,627 sf Storage= 15,717 cf

Plug-Flow detention time= 133.6 min calculated for 68,787 cf (100% of inflow)
Center-of-Mass det. time= 135.3 min (919.1 - 783.8)

Volume	Invert	Avail.Storage	Storage Description
#1	510.00'	37,555 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)
510.00	2,862	291.0	0	0	2,862
512.00	4,933	372.0	7,702	7,702	7,187
514.00	7,446	438.0	12,293	19,995	11,517
516.00	10,186	475.5	17,561	37,555	14,392

Device	Routing	Invert	Outlet Devices
#1	Secondary	515.00'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#2	Primary	507.00'	**24.0" Round Culvert** L= 75.8' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 507.00' / 505.00' S= 0.0264 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#3	Device 2	511.25'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 2	512.50'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#5	Device 2	510.90'	**6.0" Vert. Orifice/Grate** C= 0.600
#6	Device 2	515.00'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#7	Discarded	510.00'	**0.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.04 cfs @ 12.21 hrs HW=513.38' (Free Discharge)
└─**7=Exfiltration** (Exfiltration Controls 0.04 cfs)

Primary OutFlow Max=11.89 cfs @ 12.21 hrs HW=513.38' (Free Discharge)
└─**2=Culvert** (Passes 11.89 cfs of 35.10 cfs potential flow)
  ├─**3=Orifice/Grate** (Orifice Controls 6.88 cfs @ 6.31 fps)
  ├─**4=Orifice/Grate** (Orifice Controls 3.59 cfs @ 3.29 fps)
  ├─**5=Orifice/Grate** (Orifice Controls 1.41 cfs @ 7.20 fps)
  └─**6=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=510.00' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link AP-1: POST

Inflow Area = 690,806 sf, 31.32% Impervious, Inflow Depth = 2.84" for 10-Year event
Inflow = 33.43 cfs @ 12.18 hrs, Volume= 163,665 cf
Primary = 33.43 cfs @ 12.18 hrs, Volume= 163,665 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=210,598 sf 75.39% Impervious Runoff Depth=5.15"
Tc=6.0 min CN=92 Runoff=26.70 cfs 90,349 cf

Subcatchment 2S: Runoff Area=61,657 sf 73.02% Impervious Runoff Depth=5.15"
Tc=6.0 min CN=92 Runoff=7.82 cfs 26,451 cf

Subcatchment 3S: Runoff Area=93,450 sf 8.36% Impervious Runoff Depth=2.87"
Tc=6.0 min CN=70 Runoff=7.05 cfs 22,341 cf

Subcatchment 4S: Runoff Area=325,101 sf 1.46% Impervious Runoff Depth=3.45"
Flow Length=1,461' Tc=16.4 min CN=76 Runoff=21.91 cfs 93,446 cf

Pond 1P: Basin 1 Peak Elev=513.91' Storage=19,356 cf Inflow=26.70 cfs 90,349 cf
Discarded=0.05 cfs 5,257 cf Primary=14.69 cfs 85,071 cf Secondary=0.00 cfs 0 cf Outflow=14.73 cfs 90,328 cf

Link AP-1: POST Inflow=45.63 cfs 227,309 cf
Primary=45.63 cfs 227,309 cf

Total Runoff Area = 690,806 sf Runoff Volume = 232,587 cf Average Runoff Depth = 4.04"
68.68% Pervious = 474,457 sf 31.32% Impervious = 216,349 sf

Summary for Subcatchment 1S:

Runoff = 26.70 cfs @ 12.09 hrs, Volume= 90,349 cf, Depth= 5.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.08"

Area (sf)	CN	Description
16,427	98	Unconnected roofs, HSG B
12,373	98	Unconnected roofs, HSG C
64,769	98	Paved parking, HSG B
65,170	98	Paved parking, HSG C
22	98	Paved parking, HSG D
13,907	61	>75% Grass cover, Good, HSG B
26,197	74	>75% Grass cover, Good, HSG C
11,733	80	>75% Grass cover, Good, HSG D
210,598	92	Weighted Average
51,837		24.61% Pervious Area
158,761		75.39% Impervious Area
28,800		18.14% Unconnected

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

Summary for Subcatchment 2S:

Runoff = 7.82 cfs @ 12.09 hrs, Volume= 26,451 cf, Depth= 5.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.08"

Area (sf)	CN	Description
31,315	98	Paved parking, HSG B
13,704	98	Paved parking, HSG D
2,149	61	>75% Grass cover, Good, HSG B
14,489	80	>75% Grass cover, Good, HSG D
61,657	92	Weighted Average
16,638		26.98% Pervious Area
45,019		73.02% Impervious Area

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

Summary for Subcatchment 3S:

Runoff = 7.05 cfs @ 12.09 hrs, Volume= 22,341 cf, Depth= 2.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.08"

Area (sf)	CN	Description
6,044	96	Gravel surface, HSG C
5,323	98	Paved parking, HSG B
1	98	Paved parking, HSG C
2,484	98	Paved parking, HSG D
43,595	61	>75% Grass cover, Good, HSG B
18,013	74	>75% Grass cover, Good, HSG C
2,457	80	>75% Grass cover, Good, HSG D
6,639	55	Woods, Good, HSG B
8,894	70	Woods, Good, HSG C
93,450	70	Weighted Average
85,642		91.64% Pervious Area
7,808		8.36% Impervious Area

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

Summary for Subcatchment 4S:

Runoff = 21.91 cfs @ 12.23 hrs, Volume= 93,446 cf, Depth= 3.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.08"

Area (sf)	CN	Description
39,071	96	Gravel surface, HSG C
4,761	98	Paved parking, HSG C
111,211	74	>75% Grass cover, Good, HSG C
18,335	80	>75% Grass cover, Good, HSG D
203	30	Woods, Good, HSG A
138,129	70	Woods, Good, HSG C
13,391	77	Woods, Good, HSG D
325,101	76	Weighted Average
320,340		98.54% Pervious Area
4,761		1.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
1.8	314	0.0330	2.92		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.9	236	0.0161	2.04		**Shallow Concentrated Flow, SEGMENT G** Unpaved Kv= 16.1 fps
1.2	364	0.0930	4.91		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.4	82	0.0556	3.80		**Shallow Concentrated Flow, SEGMENT I** Unpaved Kv= 16.1 fps
16.4	1,461	Total			

Summary for Pond 1P: Basin 1

Inflow Area = 210,598 sf, 75.39% Impervious, Inflow Depth = 5.15" for 25-Year event
Inflow = 26.70 cfs @ 12.09 hrs, Volume= 90,349 cf
Outflow = 14.73 cfs @ 12.22 hrs, Volume= 90,328 cf, Atten= 45%, Lag= 7.8 min
Discarded = 0.05 cfs @ 12.22 hrs, Volume= 5,257 cf
Primary = 14.69 cfs @ 12.22 hrs, Volume= 85,071 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 513.91' @ 12.22 hrs Surf.Area= 7,327 sf Storage= 19,356 cf

Plug-Flow detention time= 110.9 min calculated for 90,328 cf (100% of inflow)
Center-of-Mass det. time= 110.8 min (887.5 - 776.8)

Volume	Invert	Avail.Storage	Storage Description
#1	510.00'	37,555 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)
510.00	2,862	291.0	0	0	2,862
512.00	4,933	372.0	7,702	7,702	7,187
514.00	7,446	438.0	12,293	19,995	11,517
516.00	10,186	475.5	17,561	37,555	14,392

Device	Routing	Invert	Outlet Devices
#1	Secondary	515.00'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#2	Primary	507.00'	**24.0" Round Culvert** L= 75.8' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 507.00' / 505.00' S= 0.0264 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#3	Device 2	511.25'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 2	512.50'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#5	Device 2	510.90'	**6.0" Vert. Orifice/Grate** C= 0.600
#6	Device 2	515.00'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#7	Discarded	510.00'	**0.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.05 cfs @ 12.22 hrs HW=513.90' (Free Discharge)
↑—**7=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=14.63 cfs @ 12.22 hrs HW=513.90' (Free Discharge)
↑—**2=Culvert** (Passes 14.63 cfs of 36.75 cfs potential flow)
  ↑—**3=Orifice/Grate** (Orifice Controls 7.85 cfs @ 7.20 fps)
  —**4=Orifice/Grate** (Orifice Controls 5.21 cfs @ 4.78 fps)
  —**5=Orifice/Grate** (Orifice Controls 1.57 cfs @ 7.99 fps)
  —**6=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=510.00' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link AP-1: POST

Inflow Area = 690,806 sf, 31.32% Impervious, Inflow Depth = 3.95" for 25-Year event
Inflow = 45.63 cfs @ 12.17 hrs, Volume= 227,309 cf
Primary = 45.63 cfs @ 12.17 hrs, Volume= 227,309 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Runoff Area=210,598 sf 75.39% Impervious Runoff Depth=7.68"
Tc=6.0 min CN=92 Runoff=38.92 cfs 134,739 cf

Subcatchment 2S: Runoff Area=61,657 sf 73.02% Impervious Runoff Depth=7.68"
Tc=6.0 min CN=92 Runoff=11.40 cfs 39,448 cf

Subcatchment 3S: Runoff Area=93,450 sf 8.36% Impervious Runoff Depth=5.02"
Tc=6.0 min CN=70 Runoff=12.36 cfs 39,086 cf

Subcatchment 4S: Runoff Area=325,101 sf 1.46% Impervious Runoff Depth=5.74"
Flow Length=1,461' Tc=16.4 min CN=76 Runoff=36.40 cfs 155,604 cf

Pond 1P: Basin 1 Peak Elev=514.96' Storage=27,731 cf Inflow=38.92 cfs 134,739 cf
Discarded=0.05 cfs 5,453 cf Primary=18.88 cfs 129,263 cf Secondary=0.00 cfs 0 cf Outflow=18.94 cfs 134,716 cf

Link AP-1: POST Inflow=69.59 cfs 363,400 cf
Primary=69.59 cfs 363,400 cf

Total Runoff Area = 690,806 sf Runoff Volume = 368,877 cf Average Runoff Depth = 6.41"
68.68% Pervious = 474,457 sf 31.32% Impervious = 216,349 sf

Summary for Subcatchment 1S:

Runoff = 38.92 cfs @ 12.09 hrs, Volume= 134,739 cf, Depth= 7.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.64"

Area (sf)	CN	Description
16,427	98	Unconnected roofs, HSG B
12,373	98	Unconnected roofs, HSG C
64,769	98	Paved parking, HSG B
65,170	98	Paved parking, HSG C
22	98	Paved parking, HSG D
13,907	61	>75% Grass cover, Good, HSG B
26,197	74	>75% Grass cover, Good, HSG C
11,733	80	>75% Grass cover, Good, HSG D
210,598	92	Weighted Average
51,837		24.61% Pervious Area
158,761		75.39% Impervious Area
28,800		18.14% Unconnected

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

Summary for Subcatchment 2S:

Runoff = 11.40 cfs @ 12.09 hrs, Volume= 39,448 cf, Depth= 7.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.64"

Area (sf)	CN	Description
31,315	98	Paved parking, HSG B
13,704	98	Paved parking, HSG D
2,149	61	>75% Grass cover, Good, HSG B
14,489	80	>75% Grass cover, Good, HSG D
61,657	92	Weighted Average
16,638		26.98% Pervious Area
45,019		73.02% Impervious Area

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

Summary for Subcatchment 3S:

Runoff = 12.36 cfs @ 12.09 hrs, Volume= 39,086 cf, Depth= 5.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.64"

Area (sf)	CN	Description
6,044	96	Gravel surface, HSG C
5,323	98	Paved parking, HSG B
1	98	Paved parking, HSG C
2,484	98	Paved parking, HSG D
43,595	61	>75% Grass cover, Good, HSG B
18,013	74	>75% Grass cover, Good, HSG C
2,457	80	>75% Grass cover, Good, HSG D
6,639	55	Woods, Good, HSG B
8,894	70	Woods, Good, HSG C
93,450	70	Weighted Average
85,642		91.64% Pervious Area
7,808		8.36% Impervious Area

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

Summary for Subcatchment 4S:

Runoff = 36.40 cfs @ 12.22 hrs, Volume= 155,604 cf, Depth= 5.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.64"

Area (sf)	CN	Description
39,071	96	Gravel surface, HSG C
4,761	98	Paved parking, HSG C
111,211	74	>75% Grass cover, Good, HSG C
18,335	80	>75% Grass cover, Good, HSG D
203	30	Woods, Good, HSG A
138,129	70	Woods, Good, HSG C
13,391	77	Woods, Good, HSG D
325,101	76	Weighted Average
320,340		98.54% Pervious Area
4,761		1.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.3	50	0.0400	0.09		**Sheet Flow, SEGMENT A** Woods: Light underbrush n= 0.400 P2= 3.20"
0.7	174	0.0689	4.23		**Shallow Concentrated Flow, SEGMENT B** Unpaved Kv= 16.1 fps
0.1	64	0.4088	10.29		**Shallow Concentrated Flow, SEGMENT C** Unpaved Kv= 16.1 fps
0.6	101	0.0322	2.89		**Shallow Concentrated Flow, SEGMENT D** Unpaved Kv= 16.1 fps
0.4	76	0.0204	2.90		**Shallow Concentrated Flow, SEGMENT E** Paved Kv= 20.3 fps
1.8	314	0.0330	2.92		**Shallow Concentrated Flow, SEGMENT F** Unpaved Kv= 16.1 fps
1.9	236	0.0161	2.04		**Shallow Concentrated Flow, SEGMENT G** Unpaved Kv= 16.1 fps
1.2	364	0.0930	4.91		**Shallow Concentrated Flow, SEGMENT H** Unpaved Kv= 16.1 fps
0.4	82	0.0556	3.80		**Shallow Concentrated Flow, SEGMENT I** Unpaved Kv= 16.1 fps
16.4	1,461	Total			

Summary for Pond 1P: Basin 1

Inflow Area = 210,598 sf, 75.39% Impervious, Inflow Depth = 7.68" for 100-Year event
Inflow = 38.92 cfs @ 12.09 hrs, Volume= 134,739 cf
Outflow = 18.94 cfs @ 12.25 hrs, Volume= 134,716 cf, Atten= 51%, Lag= 9.6 min
Discarded = 0.05 cfs @ 12.25 hrs, Volume= 5,453 cf
Primary = 18.88 cfs @ 12.25 hrs, Volume= 129,263 cf
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 514.96' @ 12.25 hrs Surf.Area= 8,706 sf Storage= 27,731 cf

Plug-Flow detention time= 82.2 min calculated for 134,623 cf (100% of inflow)
Center-of-Mass det. time= 83.9 min (851.0 - 767.1)

Volume	Invert	Avail.Storage	Storage Description
#1	510.00'	37,555 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)
510.00	2,862	291.0	0	0	2,862
512.00	4,933	372.0	7,702	7,702	7,187
514.00	7,446	438.0	12,293	19,995	11,517
516.00	10,186	475.5	17,561	37,555	14,392

Device	Routing	Invert	Outlet Devices
#1	Secondary	515.00'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#2	Primary	507.00'	**24.0" Round Culvert** L= 75.8' CPP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 507.00' / 505.00' S= 0.0264 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf
#3	Device 2	511.25'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#4	Device 2	512.50'	**10.0" Vert. Orifice/Grate X 2.00** C= 0.600
#5	Device 2	510.90'	**6.0" Vert. Orifice/Grate** C= 0.600
#6	Device 2	515.00'	**24.0" x 24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#7	Discarded	510.00'	**0.270 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.05 cfs @ 12.25 hrs HW=514.96' (Free Discharge)
└─**7=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=18.88 cfs @ 12.25 hrs HW=514.96' (Free Discharge)
└─**2=Culvert** (Passes 18.88 cfs of 39.90 cfs potential flow)
  ├─**3=Orifice/Grate** (Orifice Controls 9.53 cfs @ 8.73 fps)
  ├─**4=Orifice/Grate** (Orifice Controls 7.50 cfs @ 6.88 fps)
  ├─**5=Orifice/Grate** (Orifice Controls 1.84 cfs @ 9.40 fps)
  └─**6=Orifice/Grate** (Controls 0.00 cfs)

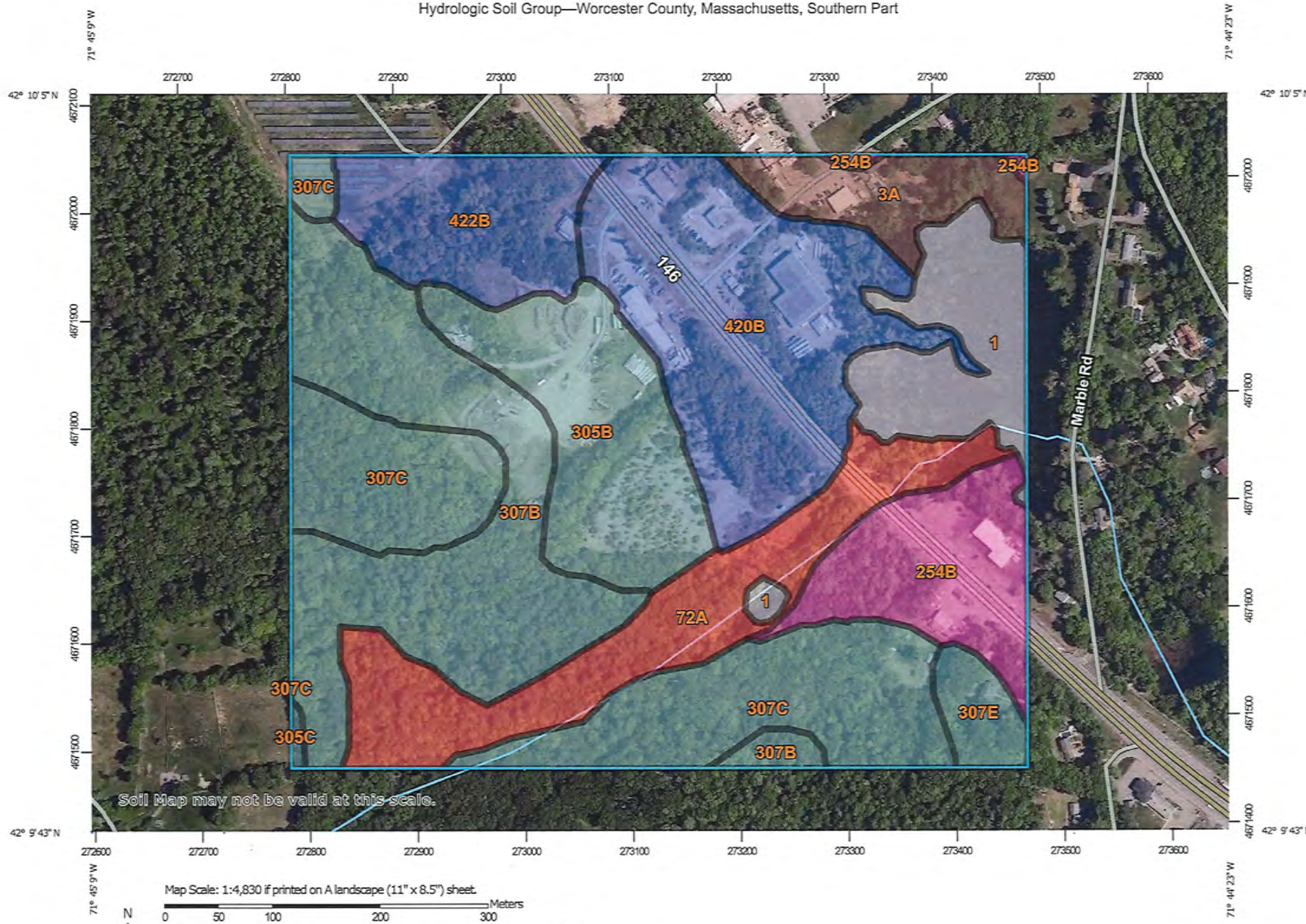
Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=510.00' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link AP-1: POST

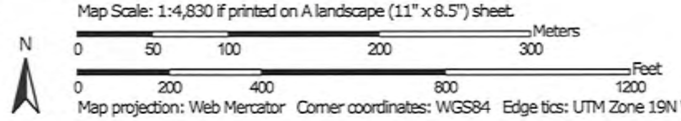
Inflow Area = 690,806 sf, 31.32% Impervious, Inflow Depth = 6.31" for 100-Year event
Inflow = 69.59 cfs @ 12.17 hrs, Volume= 363,400 cf
Primary = 69.59 cfs @ 12.17 hrs, Volume= 363,400 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Hydrologic Soil Group—Worcester County, Massachusetts, Southern Part



Map Scale: 1:4,830 if printed on A landscape (11" x 8.5") sheet.



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
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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.
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> 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)

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

Soil Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 16, Sep 10, 2023

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

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Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1	Water		6.6	6.9%
3A	Scarboro and Walpole soils, 0 to 3 percent slopes	B/D	4.2	4.3%
72A	Whitman fine sandy loam, 0 to 3 percent slopes	D	10.6	10.9%
254B	Merrimac fine sandy loam, 3 to 8 percent slopes	A	7.1	7.4%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	C	9.8	10.1%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	C	0.2	0.2%
307B	Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony	C	17.4	18.0%
307C	Paxton fine sandy loam, 8 to 15 percent slopes, extremely stony	C	15.6	16.1%
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420B	Canton fine sandy loam, 3 to 8 percent slopes	B	16.5	17.1%
422B	Canton fine sandy loam, 0 to 8 percent slopes, extremely stony	B	6.9	7.1%
Totals for Area of Interest			**96.6**	**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

Stage-Area-Storage for Pond 1P: Basin 1

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
510.00	2,862	0
510.10	2,952	291
510.20	3,044	590
510.30	3,137	900
510.40	3,231	1,218
510.50	3,327	1,546
510.60	3,424	1,883
510.70	3,523	2,231
510.80	3,623	2,588
510.90	3,725	2,955
511.00	3,827	3,333
511.10	3,932	3,721
511.20	4,037	4,119
511.30	4,144	4,529
511.40	4,253	4,948
511.50	4,363	5,379
511.60	4,474	5,821
511.70	4,587	6,274
511.80	4,701	6,738
511.90	4,816	7,214
512.00	4,933	7,702
512.10	5,046	8,201
512.20	5,161	8,711
512.30	5,277	9,233
512.40	5,394	9,766
512.50	5,513	10,312
512.60	5,633	10,869
512.70	5,754	11,438
512.80	5,876	12,020
512.90	6,000	12,614
513.00	6,125	13,220
513.10	6,251	13,839
513.20	6,379	14,470
513.30	6,508	15,115
513.40	6,638	15,772
513.50	6,769	16,442
513.60	6,902	17,126
513.70	7,036	17,823
513.80	7,172	18,533
513.90	7,308	19,257
514.00	7,446	19,995
514.10	7,573	20,746
514.20	7,701	21,509
514.30	7,830	22,286
514.40	7,960	23,075
514.50	8,091	23,878
514.60	8,223	24,693
514.70	8,356	25,522
514.80	8,491	26,365
514.90	8,626	27,221
515.00	8,762	28,090
515.10	8,900	28,973
515.20	9,039	29,870
515.30	9,178	30,781
515.40	9,319	31,706
515.50	9,461	32,645
515.60	9,604	33,598
515.70	9,748	34,565
515.80	9,893	35,547
515.90	10,039	36,544
516.00	**10,186**	**37,555**

PART III - SUPPLEMENTAL DOCUMENTATION

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.

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

COMMONWEALTH OF MASSACHUSETTS
RICHARD M. MAINVILLE
CIVIL
No. 28323
REGISTERED
PROFESSIONAL ENGINEER

Signature and Date

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.

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

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 (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.

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☐ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☒ Description and delineation of public safety features;
- ☒ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

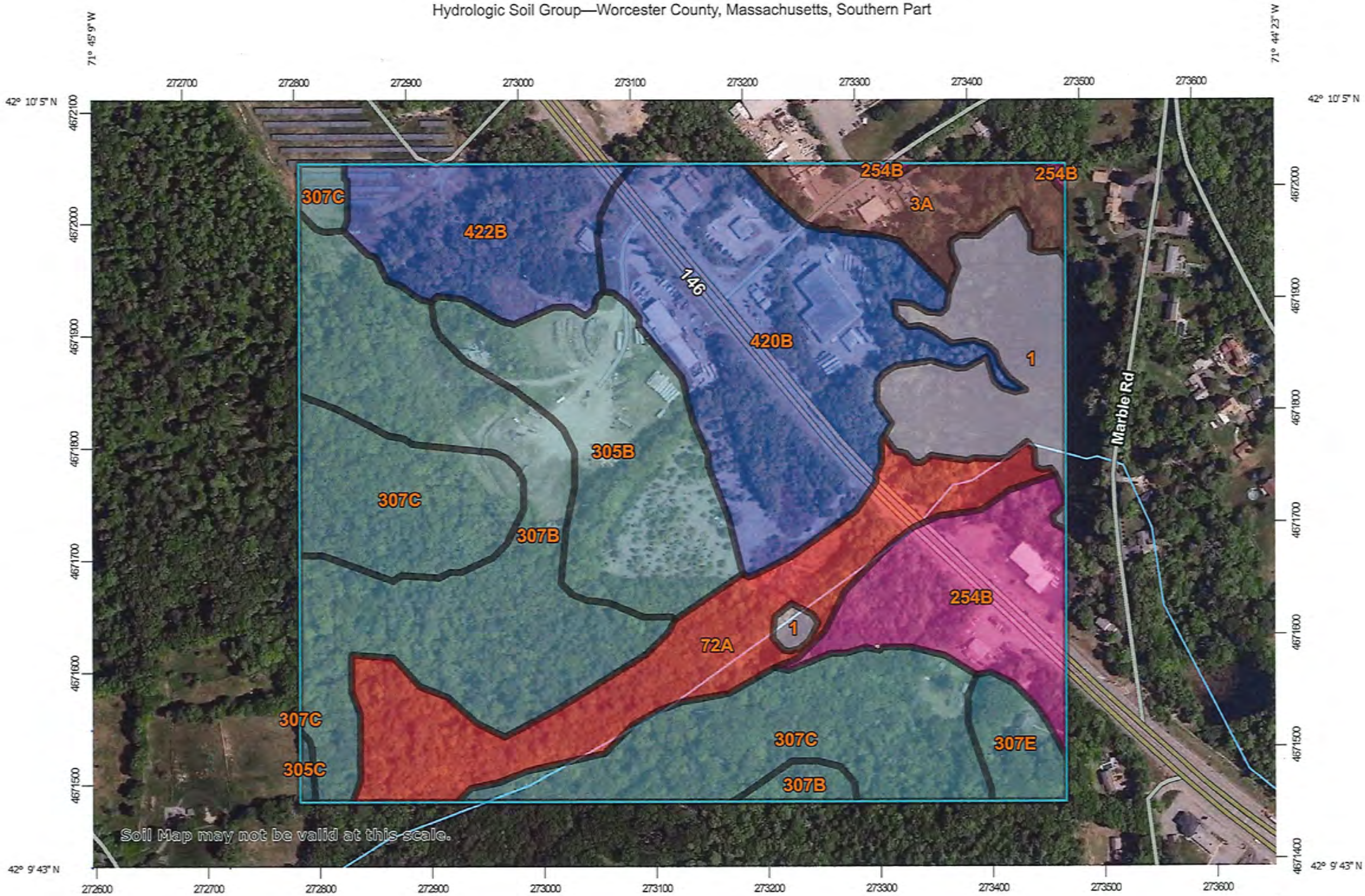
- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☒ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.



Map Scale: 1:4,830 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

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

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- Area of Interest (AOI)

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Background

- Aerial Photography

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Survey Area Data: Version 16, Sep 10, 2023

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

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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

From	To	Area (AC.) Incremental	Weighted Runoff Coefficient "C"	CxA	Cumulative CxA	Pipe Length (Feet)	Flow Time (min) To Inlet	Flow Time (min) In Channel	Design Storm (Year)	Intensity (IN/HR)	Q (CFS)	Size (IN)	Slope (FT/FT)	Mannings n	Full Capacity (cfs)	Full Velocity (fps)	Upper End Rim	Upper End Invert	Lower End Rim	Lower End Invert
CB3	DMH2	0.13	0.78	0.10	0.10	13.50	6.0	0.03	25	6.30	0.64	12	0.0222	0.013	5.31	6.76	505.39	500.30	504.54	500.00
DCB4	DMH2	0.53	0.75	0.39	0.39	27.20	6.0	0.05	25	6.30	2.47	12	0.0478	0.013	7.79	9.92	505.39	501.30	504.54	500.00
DMH2	DMH1	--	--	--	0.49	106.70	6.0	0.18	25	6.30	3.11	12	0.0483	0.013	7.83	9.97	504.54	499.90	499.00	494.75
CB1	DMH1	0.08	0.78	0.06	0.06	16.70	6.0	0.06	25	6.30	0.38	12	0.0090	0.013	3.38	4.30	498.35	494.90	499.00	494.75
DCB2	DMH1	0.62	0.70	0.44	0.44	25.20	6.0	0.05	25	6.30	2.75	12	0.0337	0.013	6.54	8.33	499.59	495.60	499.00	494.75
DMH1	HD2	--	--	--	0.99	3.50	6.2	0.01	25	6.30	6.23	12	0.0429	0.013	7.38	9.39	499.00	494.65	499.50	494.50
HD2	FES1	--	--	--	0.99	9.00	6.2	0.02	25	6.30	6.23	12	0.0444	0.013	7.51	9.56	499.50	494.40		494.00
DCB5	HD3	0.70	0.86	0.60	0.60	7.39	6.0	0.01	25	6.30	3.79	12	0.0338	0.013	6.55	8.34	517.00	514.00	517.68	513.75
CB6	HD3	0.18	0.80	0.14	0.14	36.55	6.0	0.16	25	6.30	0.89	12	0.0068	0.013	2.95	3.75	517.00	514.00	517.68	513.75
HD3	FES2	--	--	--	0.74	21.80	6.2	0.06	25	6.30	4.68	12	0.0183	0.013	4.83	6.14	517.68	513.65		513.25
CB9	DMH6	0.16	0.76	0.13	0.13	4.90	6.0	0.01	25	6.30	0.79	12	0.0204	0.013	5.09	6.48	526.68	522.20	526.90	522.10
DCB10	DMH6	0.63	0.79	0.49	0.49	113.14	6.0	0.47	25	6.30	3.11	12	0.0080	0.013	3.18	4.05	526.69	523.00	526.90	522.10
DMH6	DMH5	--	--	--	0.62	77.87	6.5	0.25	25	6.25	3.87	12	0.0128	0.013	4.04	5.14	526.90	522.00	526.92	521.00
CB8	DMH5	0.15	0.86	0.13	0.13	17.06	6.0	0.04	25	6.30	0.83	12	0.0293	0.013	6.10	7.77	526.50	521.50	526.92	521.00
DMH5	DMH4	--	--	--	0.75	56.66	6.7	0.16	25	6.15	4.62	12	0.0176	0.013	4.73	6.03	526.92	520.90	524.62	519.90
CB7	DMH4	0.23	0.88	0.21	0.21	31.11	6.0	0.08	25	6.30	1.30	12	0.0193	0.013	4.95	6.30	524.59	520.50	524.62	519.90
ROOF1	DMH4	0.33	0.90	0.30	0.30	93.82	6.0	0.18	25	6.30	1.87	12	0.0384	0.013	6.98	8.89	527.50	523.50	524.62	519.90
DMH4	DMH3	--	--	--	1.26	81.17	6.9	0.14	25	6.10	7.66	12	0.0468	0.013	7.71	9.82	524.62	519.80	521.37	516.00
DMH3	HD1	--	--	--	1.26	44.60	7.5	0.09	25	6.00	7.53	15	0.0269	0.013	10.60	8.63	521.37	515.75	520.00	514.55
HD1	FES3	--	--	--	2.74	28.50	7.6	0.05	25	6.00	16.44	18	0.0281	0.013	17.60	9.96	520.00	514.30		513.50
CB13	DMH10	0.29	0.55	0.16	0.16	81.77	6.0	0.30	25	6.30	1.01	12	0.0098	0.013	3.52	4.49	526.69	522.80	527.82	522.00
DMH10	DMH9	--	--	--	0.16	94.27	6.3	0.35	25	6.25	1.00	12	0.0095	0.013	3.48	4.43	527.82	521.90	526.59	521.00
DCB12	DMH9	0.83	0.76	0.63	0.63	10.50	6.0	0.02	25	6.30	3.99	12	0.0286	0.013	6.02	7.67	526.30	521.30	526.59	521.00
DMH9	DMH8	--	--	--	0.79	170.40	6.7	0.57	25	6.20	4.91	15	0.0091	0.013	6.16	5.02	526.59	520.75	524.20	519.20
ROOF2	DMH8	0.33	0.90	0.30	0.30	76.95	6.0	0.28	25	6.30	1.87	12	0.0104	0.013	3.63	4.63	524.00	520.00	524.20	519.20
DMH8	DMH7	--	--	--	1.09	98.80	7.2	0.18	25	6.00	6.54	15	0.0288	0.013	10.97	8.94	524.20	519.10	521.50	516.25
DCB11	DMH7	0.44	0.90	0.39	0.39	11.30	6.0	0.02	25	6.30	2.49	12	0.0442	0.013	7.49	9.54	521.37	516.75	521.50	516.25
DMH7	HD1	--	--	--	1.48	44.40	7.4	0.08	25	6.00	8.91	15	0.0327	0.013	11.67	9.51	521.50	516.00	520.00	514.55

Northeast Great Dane - Sutton, MA
TPE# 1126

FES1

Do=	1 ft
Q=	6.3 cfs (25-yr Storm)
Tw=	0.5 ft

$La=1.7Q/(Do^{3/2})+8Do$

La= 18.71 ft

$W=3Do+0.4La$

W= 10.48 ft

$d50=(0.02/Tw)*((Q/Do)^{4/3})$

d50= 0.47 ft
5.59 in

FES2

Do=	1 ft
Q=	4.7 cfs (25-yr Storm)
Tw=	0.5 ft

$La=1.7Q/(Do^{3/2})+8Do$

La= 15.99 ft

$W=3Do+0.4La$

W= 9.40 ft

$d50=(0.02/Tw)*((Q/Do)^{4/3})$

d50= 0.31 ft
3.78 in

FES3

Do=	1.5 ft
Q=	16.5 cfs (25-yr Storm)
Tw=	0.75 ft

$La=1.7Q/(Do^{3/2})+8Do$

La= 27.27 ft

$W=3Do+0.4La$

W= 15.41 ft

$d50=(0.02/Tw)*((Q/Do)^{4/3})$

d50= 0.65 ft
7.83 in

FES4

Do=	2 ft
Q=	19 cfs (100-yr Storm)
Tw=	1 ft

$La=1.7Q/(Do^{3/2})+8Do$ C CO

La= 27.42 ft

$W=3Do+0.4La$

W= 16.97 ft

$d50=(0.02/Tw)*((Q/Do)^{4/3})$

d50= 0.40 ft
4.83 in

TSS REMOVAL WORKSHEET PRIOR TO INFILTRATION (Inf. Basin 1)

A	B	C	D	E
BMP	**TSS Removal Rate**	**Starting TSS Load***	**Amount Removed (B x C)**	**Remaining Load (C - D)**
Deep sump CB's w/ hoods	25.0%	100.0%	25.0%	75.0%
HD1 (HD4)	91.0%	75.0%	68.3%	6.8%
		Total TSS Removal =	93.3%	

* Equals remaining load from previous BMP (E)

TSS REMOVAL WORKSHEET PRIOR TO DISCHARGE (Inf. Basin 1)

A	B	C	D	E
BMP	**TSS Removal Rate**	**Starting TSS Load***	**Amount Removed (B x C)**	**Remaining Load (C - D)**
Deep sump CB's w/ hoods	25.0%	100.0%	25.0%	75.0%
HD1 (HD6)	91.0%	75.0%	68.3%	6.8%
Infiltration Basin	80.0%	6.8%	5.4%	1.4%
		Total TSS Removal =	98.7%	

* Equals remaining load from previous BMP (E)

TSS REMOVAL WORKSHEET PRIOR TO DISCHARGE

A	B	C	D	E
BMP	**TSS Removal Rate**	**Starting TSS Load***	**Amount Removed (B x C)**	**Remaining Load (C - D)**
Deep sump CB's w/ hoods	25.0%	100.0%	25.0%	75.0%
HydroDome HD2 & HD3	80.0%	75.0%	60.0%	15.0%
		Total TSS Removal =	85.0%	

* Equals remaining load from previous BMP (E)

Hydroworks

Technical Design Submission

Northeast Great Dane
Sutton, MA

Revised
12/19/2023

Hydroworks, LLC

Hydroworks Technical Submission for Northeast Great Dane

Hydroworks is pleased to make a submission regarding the stormwater treatment structure for Northeast Great Dane in Sutton, MA. We propose the use of a HD 6 and two HS 4 hydrodynamic separator for this project. Sizing calculations were based on annual TSS removal and treatment of the MADEP water quality flow rate.

Hydroworks HydroDome Operation

HydroDome is unique since it provides benefits for both water quality and water quantity or flow control. HydroDome comes complete and simply slides into the outlet pipe from a drainage structure and is secured to the wall with two anchor bolts. (Figure 1).

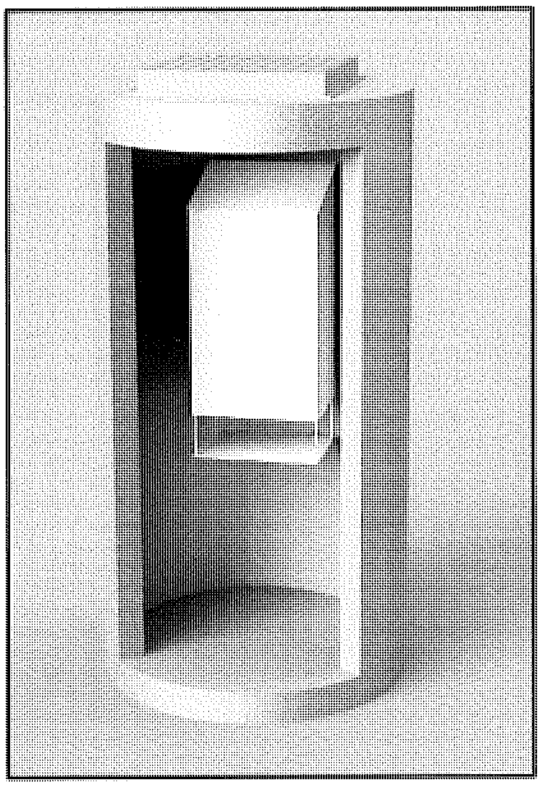


Figure 1. Hydroworks HydroDome

HydroDome consists of two main components:

1. A siphon with flow control
2. A flow weir (main flow path)

At the heart of HydroDome is a siphon that regulates the water level in the structure and the flow rate leaving the structure. (Figure 2)

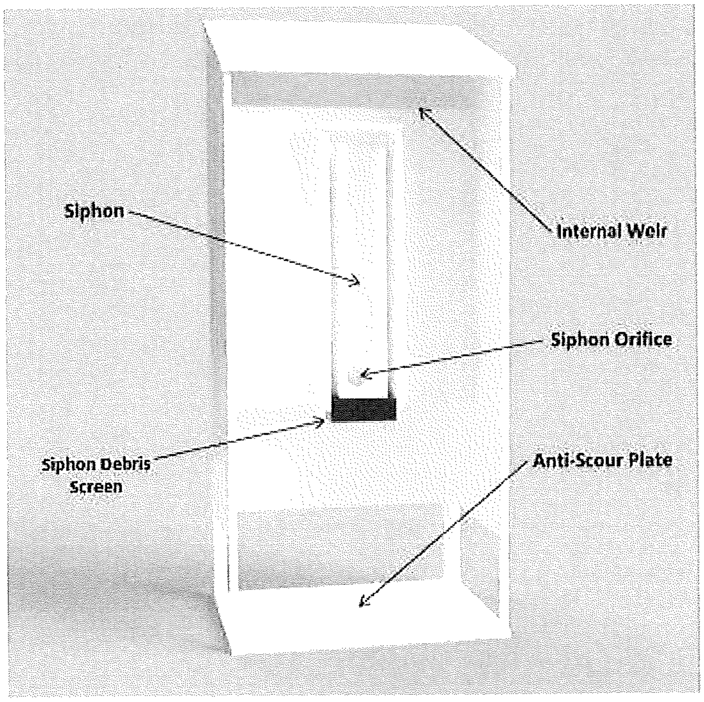


Figure 2 HydroDome Components

The siphon raises the water level to a pre-determined level without allowing water to exit the structure. The raised water level provides greater time for initial TSS removal, reduces inlet velocities by increasing the area of flow in the upstream pipe, and provides a greater volume or buffer of water to prevent scour of previously settled solids.

Water flows into the device through horizontal openings at the bottom of the HydroDome. Water then must travel upwards through a siphon. A debris screen is located at the entrance to the siphon to provide secondary protection for the siphon (primary protection provided by the body of the HydroDome itself). Once the water level reaches a pre-determined height the siphon begins to engage and water flows out of the structure downstream. The siphon flow is controlled by an orifice whose size can be changed to provide the desired flow control. The water level continues to rise since the siphon flow is regulated by a small orifice.

A weir above the siphon provides the main flow path through the separator and prevents the system from surcharging. A scour protection plate minimizes scour by preventing upward velocities/flow from the structure floor during periods of peak flow.

HydroDome combines the function of separator, hood, and flow control with active storage to provide a multi-purpose stormwater management solution in one structure.

HydroDome can be used as an inlet structure or as a regular drainage structure without any modification.

Construction Materials

The internal components of the HydroDome are made from HDPE. The shell of the structure is pre-cast concrete. Pre-cast concrete is readily accepted by all municipalities since it has the following advantages:

- long service life
- ease of installation (less dependent on backfill (contractor proficiency) for structural integrity)
- concrete structures are designed for both anti-buoyancy and traffic loading without any field requirements (such as structural loading slabs in traffic areas and anti-buoyancy slabs to prevent groundwater uplift).
- low maintenance requirements

Hydroworks HD Separator Dimensions and Capacities

The HD separator is manufactured in a variety of sizes from 4 ft inside diameter to 12 ft inside diameter as shown in Table 1.

Table 1. Hydroworks HD Separator Dimensions*

Model	Structure Inside Diam. (ft)	Structure Depth (ft)*	Sediment/ Sinking Trash Volume (ft^3)	Oil/Floating Trash Volume (gal)	Permanent Pool (Wet) Volume (gal)
HD 3	3	4	11	31	210
HD 4	4	4	25	70	420
HD 5	5	5.5	47	134	805
HD 6	6	6.5	80	230	1375
HD 7	7	7.5	125	360	2155
HD 8	8	8.5	188	560	3195
HD 10	10	10.5	367	1125	6165
HD 12	12	12.5	631	1975	10575

*Dimensions vary with project requirements

The volumes provided in Table 1 for oil and sediment are to full capacity and not indicative of recommended depths/volumes for maintenance.

Headloss

Any water quality system implemented in a storm drain network will create headloss in the system. In general, depending on the configuration of the by-pass, systems designed to treat high flows or all of the flow will have a higher headloss impact on the storm drain network than systems that by-pass high flows.

The headloss created by the HD separator was measured in an independent laboratory (Alden Research Laboratory) for a full-scale HD 3 (Figures 3).

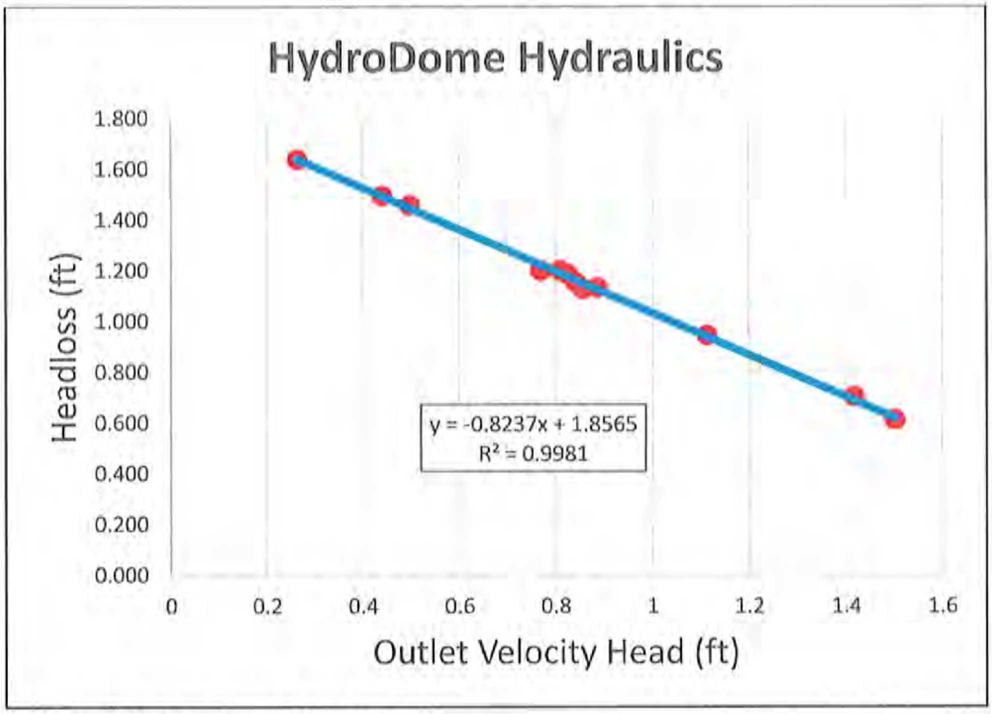


Figure 3. HydroDome Headloss

Headloss in the HydroDome decreases with velocity head due to the siphon creating an initial large headloss and the high weir reducing the headloss with increasing flow. The water level inside the HydroDome must exceed the level of the siphon for water to flow out of the structure. This creates an initially high headloss and a discontinuity between the upstream and downstream flow depths.

The sizing program calculates upstream flow head based on either the provided downstream flow rate or full pipe flow assuming the flow is not surcharged in the outlet pipe. Please contact Hydroworks to determine headloss in designs where tailwater creates a surcharge condition to ensure the headloss created by the HydroDome is acceptable for these site-specific applications.

Hydroworks HydroStorm (HS) Operation

The Hydroworks HydroStorm separator is a vortex separator with a high flow bypass. Accordingly, high flows do not scour out the fines that are settled in the low flow path since they are bypassed downstream without entering the lower chamber as shown in Figure 1.

The HS separator consists of 4 areas:

1. A pre-treatment area designed to remove coarse solids
2. An inner chamber where water enters the treatment chamber and oil is trapped
3. A lower chamber where fine solids are removed
4. A high flow bypass to convey higher flows directly downstream

Under normal or low flows, water enters a pre-treatment area with a horizontal grate. The area underneath the grate is submerged with openings to the main treatment area of the separator. Coarse solids fall through the grate and are either trapped in the pretreatment area or conveyed into the main treatment area depending on the flow rate (Figure 4A). Fines are transported into the main treatment area. Openings and weirs in the pretreatment area allow entry of water and solids into the main treatment area and cause water to rotate in the main treatment area creating a vortex motion. Water in the main treatment area is forced to rise along the walls of the separator to discharge from the treatment area to the downstream pipe.

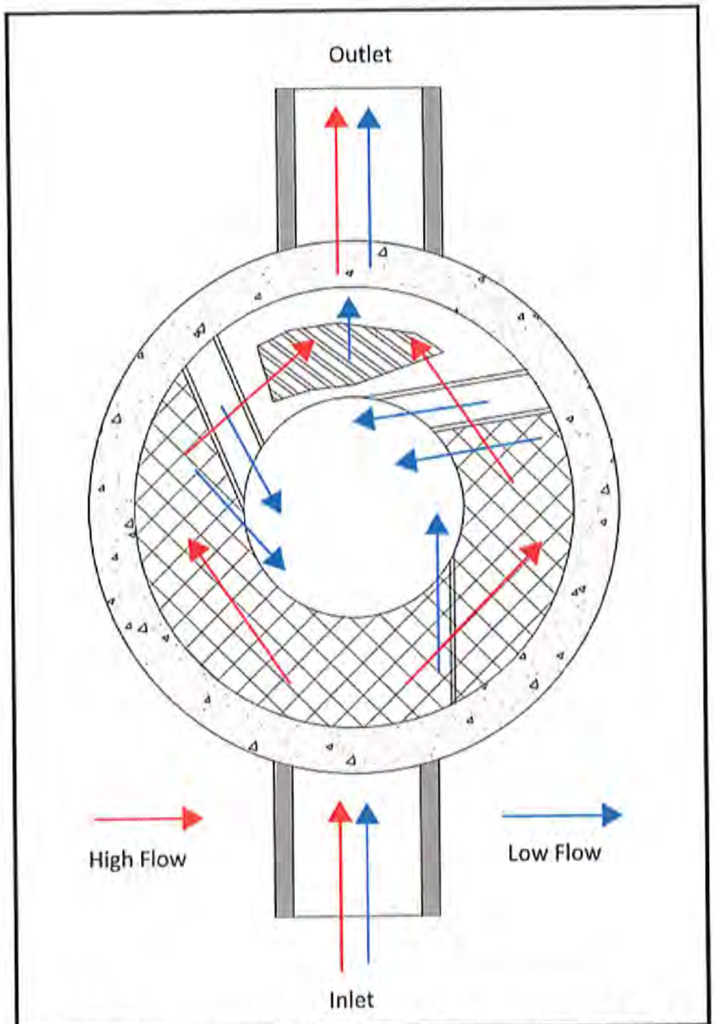


Figure 4A Hydroworks HydroStorm Operation – Plan View

The vortex motion forces solids and floatables to the middle of the inner chamber. Floatables are trapped since the inlet to the treatment area is submerged. The design maximizes the retention of settled solids since solids are forced to the center of the inner chamber by the vortex motion of water while water must flow up the walls of the separator to discharge into the downstream pipe.

A set of high flow weirs near the outlet pipe create a high flow bypass over both the pretreatment area and main treatment chamber. The rate of flow into the treatment area is regulated by the number and size of openings into the treatment chamber and the height of by-pass weirs. High flows flow over the weirs directly to the outlet pipe preventing the scour and resuspension of any fines collected in the treatment chamber.

A central tube is located in the structure to provide access for cleaning. The arrangement of the inlet area and bypass weirs near the outlet pipe facilitate the use of multiple inlet pipes. Figure 4B is a profile view of the HydroStorm separator showing the flow patterns for low and high flows.

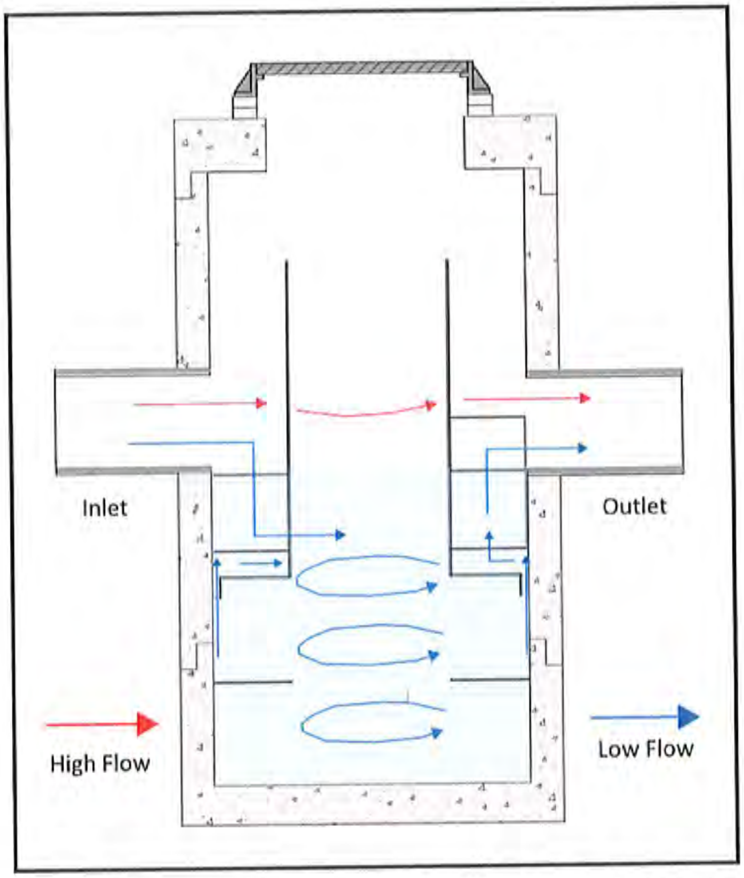


Figure 4B Hydroworks HydroStorm Operation – Profile View

The HSi is an inlet version of the HydroStorm (HS) separator (Figure 5). There is a catch-basin grate on top of the HSi. Water flows directly into the HSi from above through the catch-basin grate on top of the structure. The grate is oversized to allow maintenance of the entire structure. A funnel sits under the grate on the top cap and directs the water to the inlet side of the separator.

Water continues moving through the separator similar to a standard unit once the water falls on the upstream side of the by-pass weirs.

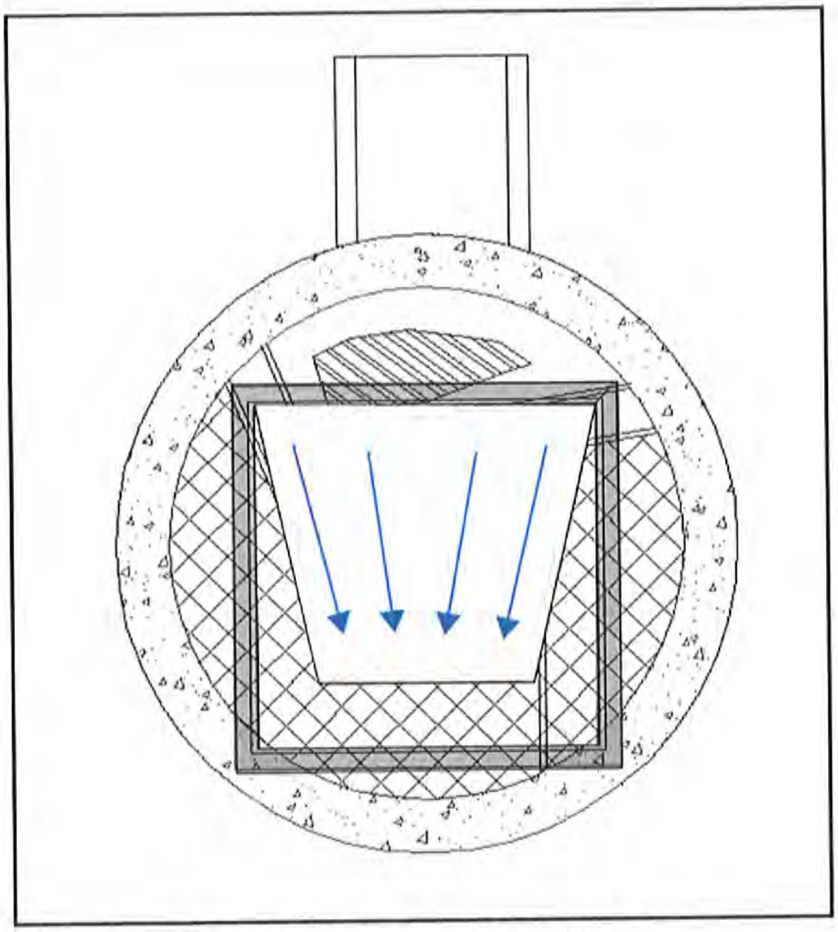


Figure 5. Hydroworks HSi Flow Path

The HSi provides the same separate flow paths for low and high flow as the other HydroStorm models. The funnel is removed for inspection and cleaning providing the exact same access for operations and maintenance as the standard HydroStorm models.

Construction Materials

The inner chamber and outlet baffle are made out of a copolymer plastic. The shell of the structure is pre-cast concrete. Pre-cast concrete is readily accepted by all municipalities since it has the following advantages:

- long service life
- ease of installation (less dependent on backfill (contractor proficiency) for structural integrity)
- concrete structures are designed for both anti-buoyancy and traffic loading without any field requirements (such as structural loading slabs in traffic areas and anti-buoyancy slabs to prevent groundwater uplift).
- low maintenance requirements

Hydroworks HS Separator Dimensions and Capacities

The HS separator is manufactured in a variety of sizes from 4 ft inside diameter to 12 ft inside diameter as shown in Table 2. Larger sizes may not be available in all areas. Please check with Hydroworks to ensure availability of the larger model sizes.

Table 2. Hydroworks HS Separator Dimensions*

Model	Structure Inside Diam. (SID) (ft)	Structure Depth (ft)*	Sediment/ Sinking Trash Volume (ft^3)	Oil/Floating Trash Volume (gal)	Permanent Pool Wet Volume (gal)
HS 4	4	4	30	95	375
HS 5	5	5	60	165	730
HS 6	6	6	110	270	1265
HS 7	7	6.5	160	410	1870
HS 8	8	7	220	615	2630
HS 10	10	9	465	1130	5285
HS 12	12	11	835	1875	9035

*Dimensions vary with project requirements

The volumes provided in Table 2 for oil and sediment are to full capacity and not indicative of recommended depths/volumes for maintenance.

Headloss

Any water quality system implemented in a storm drain network will create headloss in the system. In general, depending on the configuration of the by-pass, systems designed to treat high flows or all of the flow will have a higher headloss impact on the storm drain network than systems that by-pass high flows.

The headloss created by the HS separator was measured in an independent laboratory (Alden Research Laboratory) for a full-scale HS 4. The K value (h = K v2/(2g)) for headloss calculations was determined to be 1.04 as shown in Figure 6.

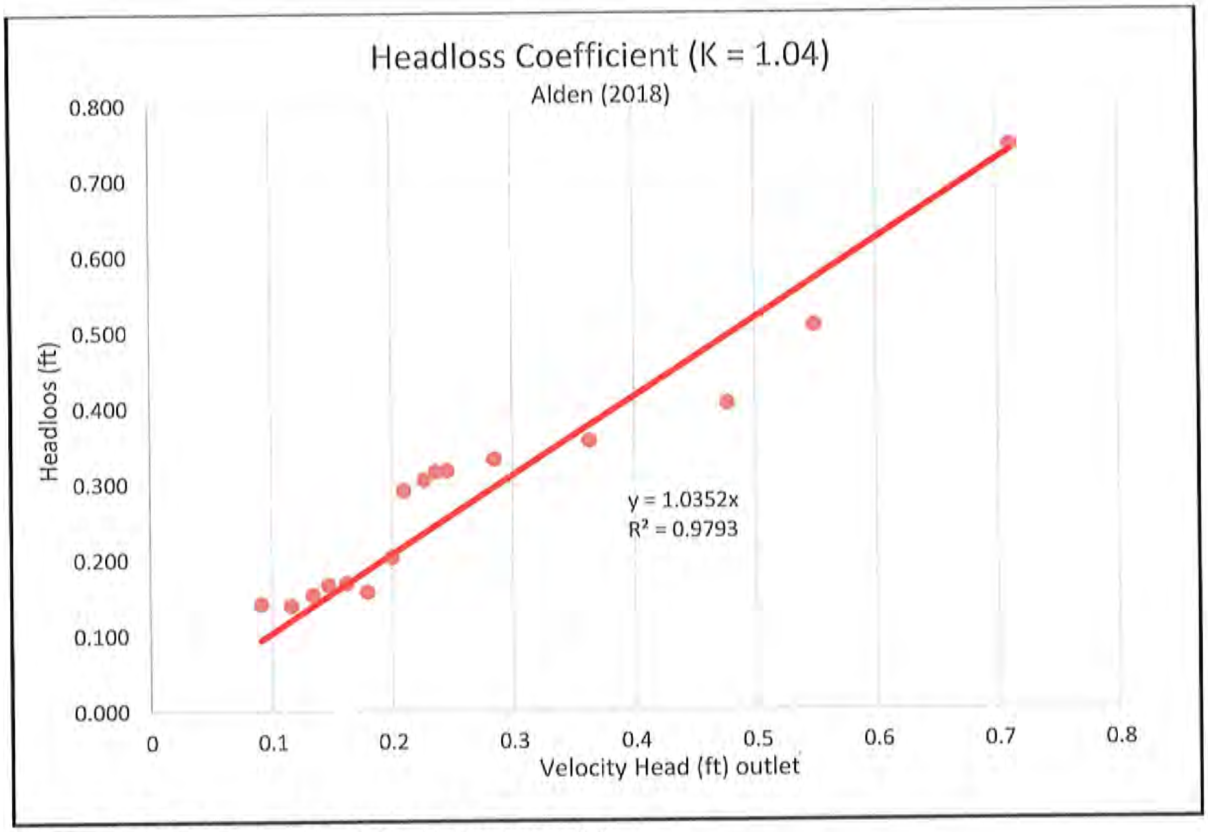


Figure 6. HydroStorm Headloss K Factor (1.04)

Site Drainage

The water quality flow and peak conveyance flow were calculated based on areas and imperviousness delineated from the site plan and the pipe sizes and slopes provided on the grading and drainage plan C-5.1 dated December 6, 2023 (Figure 7). These flows are provided in Table 3.

Table 3. Northeast Great Dane Water Quality Separator Parameters

Location	Area (ac)	Impervious (%)	Tc (min)	WQF (cfs)*	Peak Conveyance (cfs)**	Recommended Unit
HD 1	4.79	68	12	3.4	19.0	HD 6
HD 2	1.13	27	6	0.4	8.0	HS 4
HD 3	0.67	65	6	0.5	5.2	HS 4

*Based on 1" of runoff

** Based on full pipe flow (un-surcharged)

Figure 7. Northeast Great Dane Separator Drainage Areas

The HydroDome HS 4 water quality treatment rate based on NJDEP ratings is 0.9 cfs and the HD 6 is rated for a water quality flow rate of 3.4 cfs. Therefore, the HD 6 is proposed for HD 1 and HS 4 separators are proposed for HD 2 and HD 3.

A review of the hydraulics and rim elevations upstream indicate that the HydroDome will safely convey the peak conveyance flow based on the pipe sizes and slopes give for non-surcharged conditions.

TSS Removal Calculations for the Specified System

Hydroworks sizes separators based on continuous analysis of rainfall, runoff, and TSS settling in the HydroDome based on laboratory testing.

These calculations require a user input particle size distribution. We have used the NJDEP particle size distribution for this project.

Table 4. Northeast Great Dane TSS Particle Size Distribution	
Particle Size (um)	% by Mass
1	5
4	5
6	5
7	5
18	15
45	10
70	5
90	10
125	15
200	15
400	5
850	5

TSS removal calculations in the sizing program are based on the HydroDome being a completely mixed reactor vessel. The removal calculations solve a first order differential equation for the concentration of solids in the tank at any time. The first order differential equation is for continuity of mass.

$$C'V = QC_i - QC_t - r_cV$$

C' = the change in concentration of solids in the tank with time
Q = flow rate through the tank
C_i = solids concentration in the influent to the tank
C_t = solids concentration in the tank
V = tank volume
r_c = reduction in solids in the tank (TSS Removal)

Continuous simulation requires historical rainfall data. Forty-five years of rainfall data (1957-2001) from Worcester, MA, were used to analyze the Northeast Great Dane project.

Laboratory testing (Alden, 2020) results for TSS removal for the HydroDome using the NJDEP TSS distribution is provided in Figure 8. Figure 9 shows the NJDEP TSS particle size distribution tested with the HD 3.

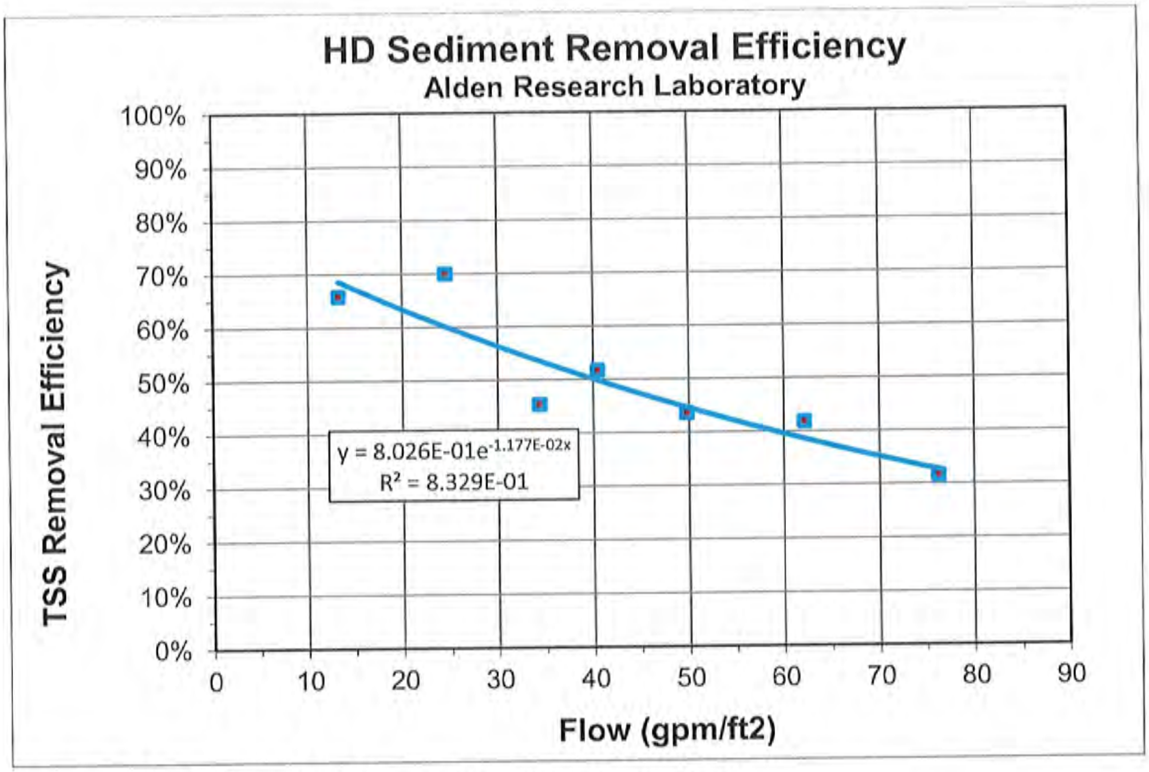


Figure 8. HydroDome TSS Removal Results (Alden, 2020)

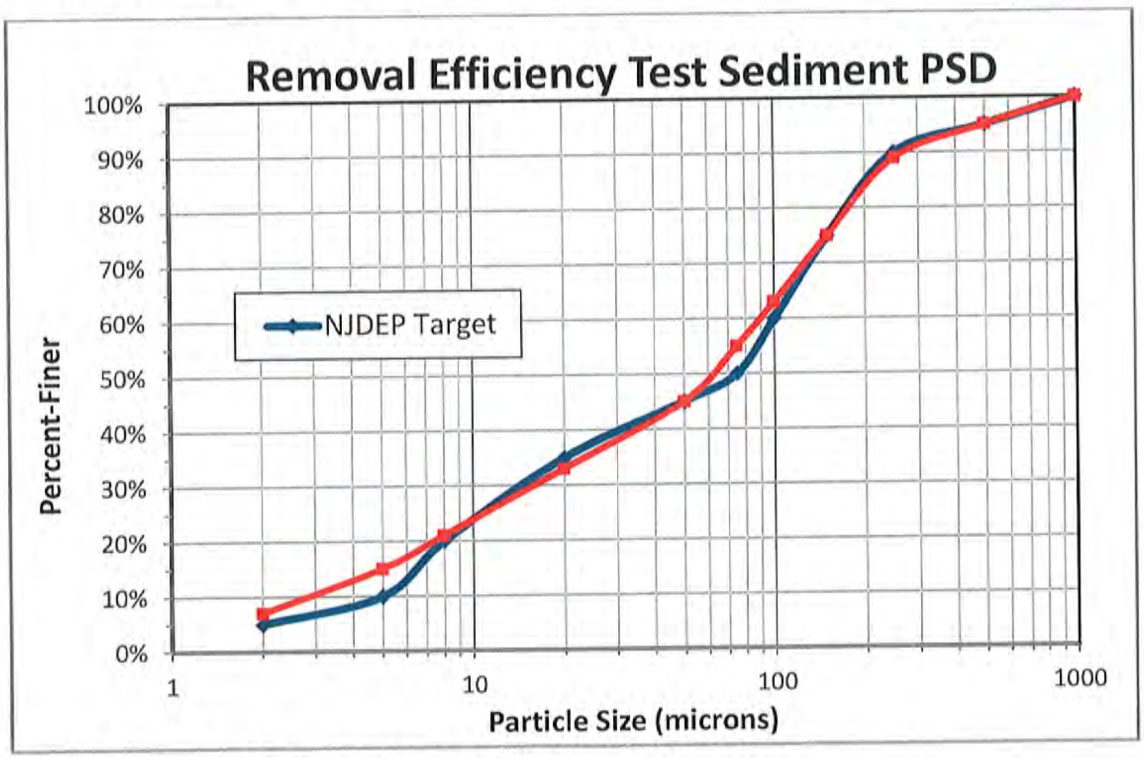


Figure 9. NJDEP TSS Particle Size Distribution (Alden, 2020)

Hydroworks uses the Peclet Number to calculate TSS removal based on the independent laboratory testing. The Peclet number has been used as a dimensionless scaling number for sediment deposition in lakes (Dhamotharan, et. Al. 1981). Others have suggested its use for scaling of TSS removal results for hydrodynamic separators (Dhanak, 2008, Gulliver, Guo and Wu, 2008, ASCE, EWRI, NJDEP).

The Peclet number is the ratio of convection (convective settling) to diffusion (turbulence keeping particles in suspension). The Peclet number (Equation 1) varies with the size of separator, particle size of TSS, and flow rate.

$$Pe = Vs\ h\ d / Q \qquad \text{Equation 1}$$

Where Pe = Peclet number
Vs = settling velocity
h = characteristic dimension
d = characteristic dimension
Q = flow rate

The Peclet number equates to surface area scaling if d and h are assumed to the length and width or diameter of a separator. A particle will be removed in the separator if the Peclet number is equal to, or greater than, the Peclet number calculated for removal of that particle based on the independent laboratory results. Based on the NJDEP PSD in Figure 9, the TSS removal in Figure 8, and the dimensions of the tested HD 3, critical Peclet Numbers can be calculated for each particle size in Figure 9 (critical Peclet number is the Peclet Number above which the particle is removed). A critical Peclet Number curve was then developed and input to the model (Figure 10).

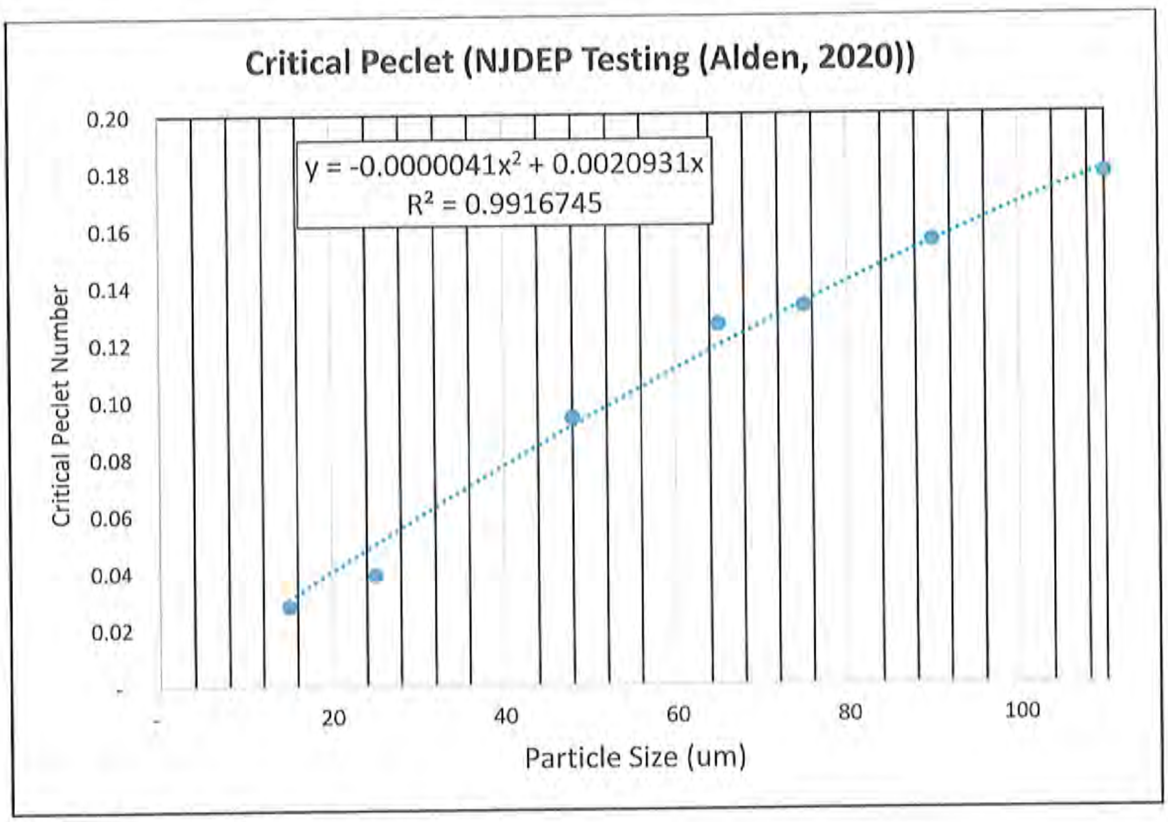


Figure 10. Critical Peclet Number Curve

At each timestep the Peclet Number is calculated for every flow and every HydroDome separator for each particle size in the design particle size distribution. The calculated Peclet Number is then compared to the Critical Peclet Number to determine if the particle is removed at that timestep or not (removed if the calculated Peclet Number is greater than the Critical Peclet Number and not removed if less than the Critical Peclet Number). These calculations are done for the entire rainfall record and all particle sizes in the distribution to determine an overall TSS removal percentage.

Hydroworks added a Peclet routine to the USEPA SWMM model to determine TSS removal based on the Peclet number calibrated to the independent laboratory testing completed by Alden Research Laboratory (regression equation in Figure 10). A comparison of the Alden test data to that predicted by the Peclet routine is given in Figure 11.

The use of the Peclet Number allows Hydroworks to size the HydroDome based on any particle size and design storm or local hydrology. The exact same process was done with the HydroStorm testing to derive a critical Peclet Number curve to size HydroStorm.

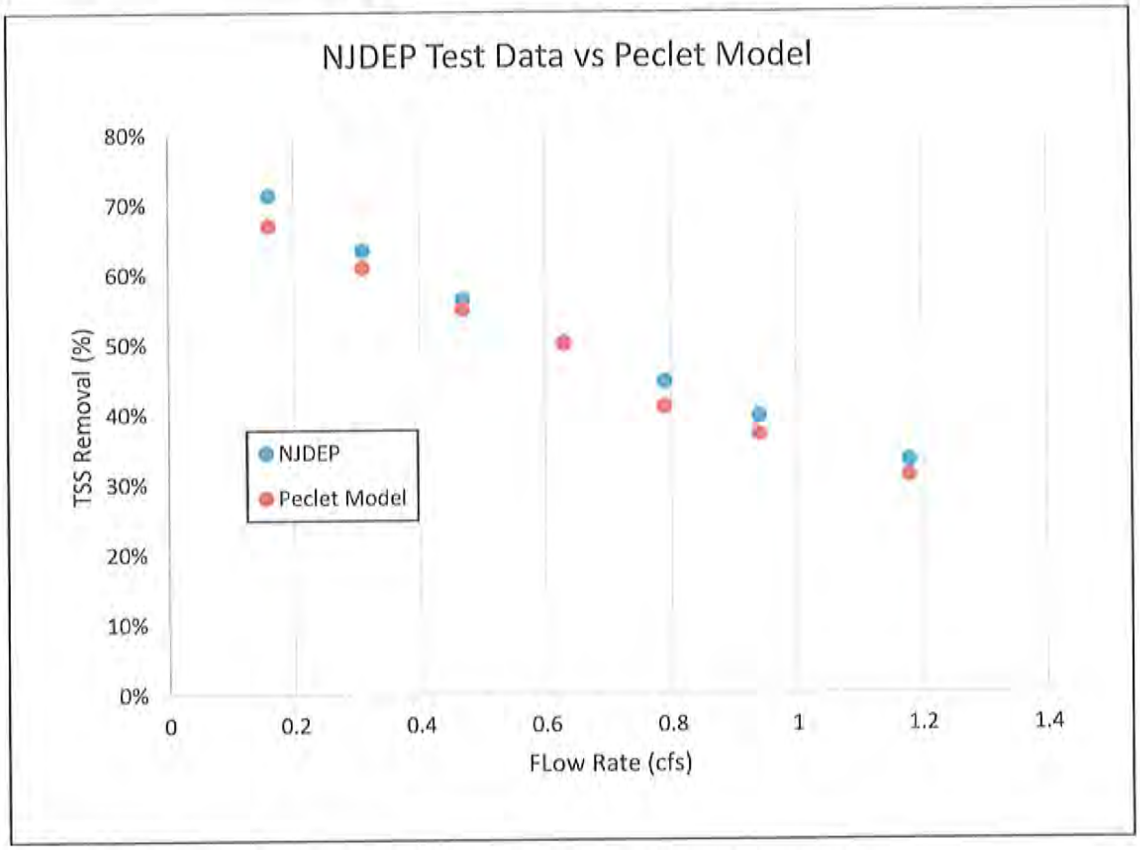
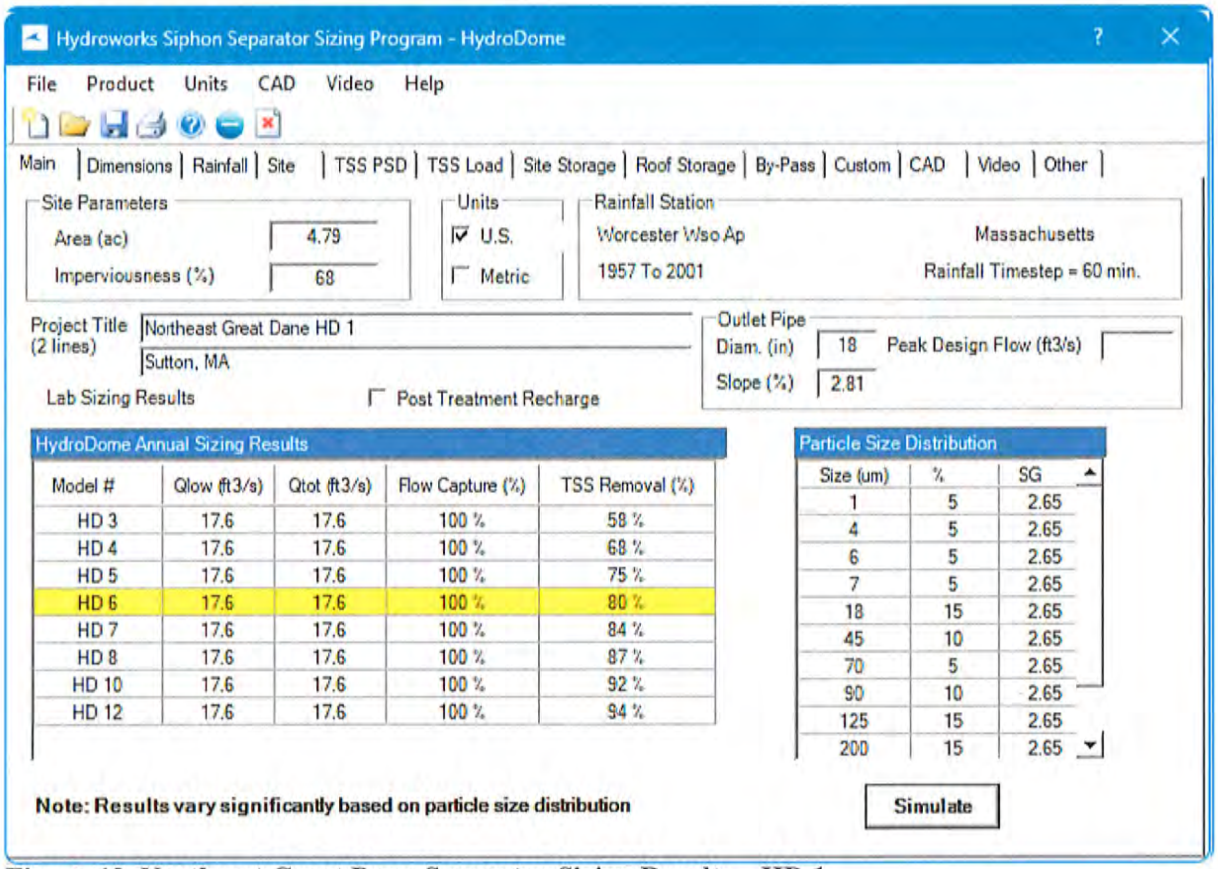


Figure 11. Comparison of NJDEP Removal Data with Peclet Model

Sizing Recommendations

TSS Removal

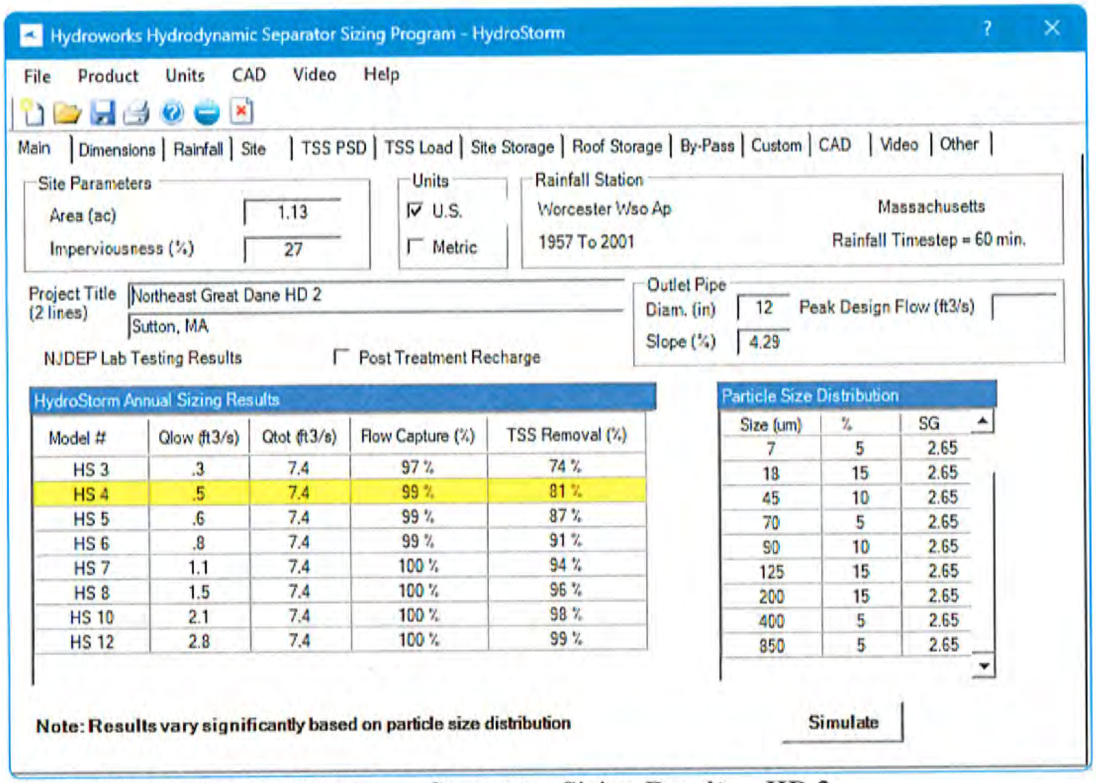
The annual TSS removal results are given in Figures 12 through 14. The sizing indicates the HD 6 is appropriately sized for HD 1 and the HS 4 is appropriately sized for HD 2 and HD 3 to provide 80% TSS removal.



Model #	Qlow (ft3/s)	Qtot (ft3/s)	Flow Capture (%)	TSS Removal (%)
HD 3	17.6	17.6	100 %	58 %
HD 4	17.6	17.6	100 %	68 %
HD 5	17.6	17.6	100 %	75 %
HD 6	17.6	17.6	100 %	80 %
HD 7	17.6	17.6	100 %	84 %
HD 8	17.6	17.6	100 %	87 %
HD 10	17.6	17.6	100 %	92 %
HD 12	17.6	17.6	100 %	94 %

Size (um)	%	SG
1	5	2.65
4	5	2.65
6	5	2.65
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65

Figure 12. Northeast Great Dane Separator Sizing Results – HD 1



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units CAD Video Help

Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

Site Parameters
Area (ac) 1.13
Imperviousness (%) 27

Units
☑ U.S.
☐ Metric

Rainfall Station
Worcester Wso Ap — Massachusetts
1957 To 2001 — Rainfall Timestep = 60 min.

Project Title (2 lines): Northeast Great Dane HD 2 / Sutton, MA

NJDEP Lab Testing Results ☐ Post Treatment Recharge

Outlet Pipe
Diam. (in) 12 Peak Design Flow (ft3/s)
Slope (%) 4.29

HydroStorm Annual Sizing Results

Model #	Qlow (ft3/s)	Qtot (ft3/s)	Flow Capture (%)	TSS Removal (%)
HS 3	.3	7.4	97 %	74 %
HS 4	.5	7.4	99 %	81 %
HS 5	.6	7.4	99 %	87 %
HS 6	.8	7.4	99 %	91 %
HS 7	1.1	7.4	100 %	94 %
HS 8	1.5	7.4	100 %	96 %
HS 10	2.1	7.4	100 %	98 %
HS 12	2.8	7.4	100 %	99 %

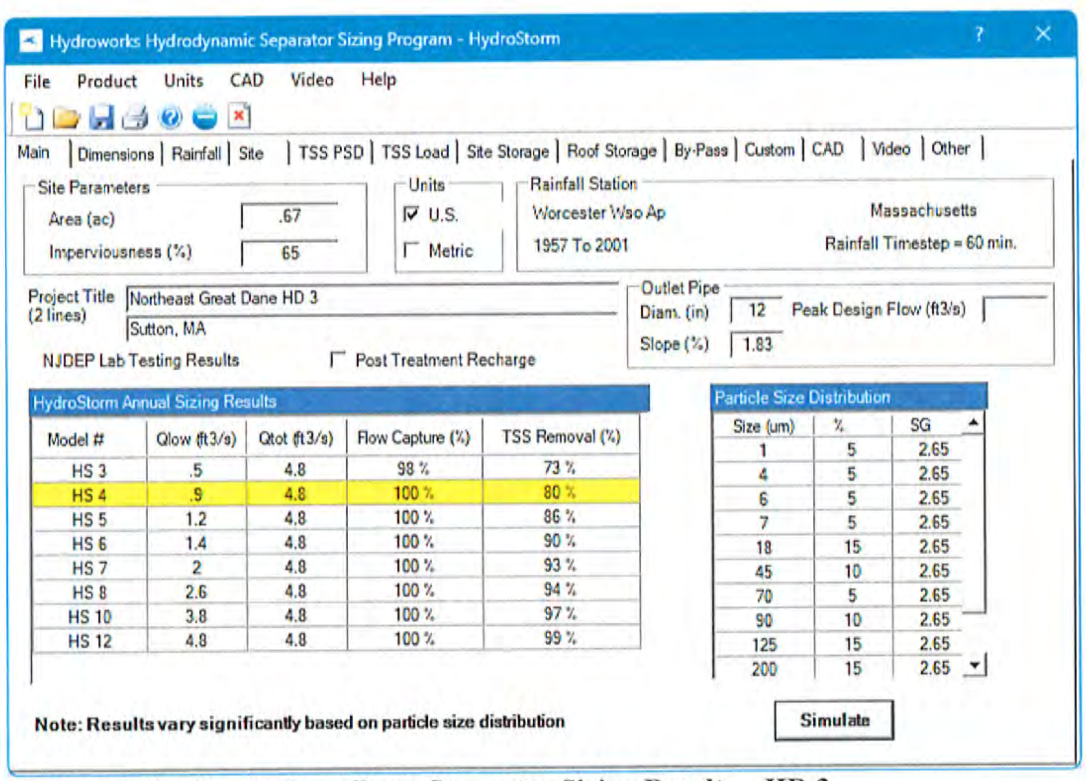
Particle Size Distribution

Size (um)	%	SG
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65
400	5	2.65
850	5	2.65

Note: Results vary significantly based on particle size distribution

Simulate

Figure 13. Northeast Great Dane Separator Sizing Results – HD 2



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units CAD Video Help

Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

Site Parameters
Area (ac) .67
Imperviousness (%) 65

Units
☑ U.S.
☐ Metric

Rainfall Station
Worcester Wso Ap — Massachusetts
1957 To 2001 — Rainfall Timestep = 60 min.

Project Title (2 lines): Northeast Great Dane HD 3 / Sutton, MA

NJDEP Lab Testing Results ☐ Post Treatment Recharge

Outlet Pipe
Diam. (in) 12 Peak Design Flow (ft3/s)
Slope (%) 1.83

HydroStorm Annual Sizing Results

Model #	Qlow (ft3/s)	Qtot (ft3/s)	Flow Capture (%)	TSS Removal (%)
HS 3	.5	4.8	98 %	73 %
HS 4	.9	4.8	100 %	80 %
HS 5	1.2	4.8	100 %	86 %
HS 6	1.4	4.8	100 %	90 %
HS 7	2	4.8	100 %	93 %
HS 8	2.6	4.8	100 %	94 %
HS 10	3.8	4.8	100 %	97 %
HS 12	4.8	4.8	100 %	99 %

Particle Size Distribution

Size (um)	%	SG
1	5	2.65
4	5	2.65
6	5	2.65
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65

Note: Results vary significantly based on particle size distribution

Simulate

Figure 14. Northeast Great Dane Separator Sizing Results – HD 3

Local Production

Hydroworks units are made locally by STI Precast in Massachusetts, United Concrete in Connecticut and Concrete Systems Inc. in New Hampshire. Many of the Hydroworks internal components are made in Massachusetts. Therefore, the use of HydroDome supports the local New England economy.

Summary

We propose the use of a HydroDome HD 6 separator for HD 1 and a HS 4 separator at HD 2 and HD 3 for the Northeast Great Dane project in Sutton, MA. The proposed HydroDome separators are properly sized for TSS removal and treat the MADEQ water quality flow rate.

APPENDIX 1

Hydroworks Approvals

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATERSHED PROTECTION AND RESTORATION
BUREAU OF NJPDES STORMWATER PERMITTING & WATER QUALITY MANAGEMENT
P.O. Box 420 Mail Code 401-02B
Trenton, New Jersey 08625-0420
609-633-7021 / Fax: 609-777-0432
www.njstormwater.org

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

SHAWN M. LATOURETTE
Commissioner

June 30, 2021

Graham Bryant
President
Hydroworks, LLC
257 Cox Street
Roselle, NJ 07203

Re: MTD Lab Certification
HydroDome (HD) Stormwater Separator by Hydroworks, LLC
On-line Installation

TSS Removal Rate 50%

Dear Mr. Bryant:

The Stormwater Management rules under N.J.A.C. 7:8-5.2(f) and 5.2(j) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). Hydroworks, LLC has requested an MTD Laboratory Certification for the HydroDome Stormwater Separator (HydroDome).

The project falls under the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advance Technology" dated January 25, 2013. The applicable protocol is the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" dated January 25, 2013.

NJCAT verification documents submitted to the NJDEP indicate that the requirements of the protocol have been met or exceeded. The NJCAT letter also included a recommended certification TSS removal rate and the required maintenance plan. The NJCAT Verification Report dated May 2021 with the Verification Appendix for this device is published online at http://www.njcat.org/verification-process/technology-verification-database.html.

The NJDEP certifies the use of the HydroDome by Hydroworks, LLC at a TSS removal rate of 50% when designed, operated and maintained in accordance with the information provided in the Verification Appendix and the following conditions:

1. The maximum treatment flow rate (MTFR) for the manufactured treatment device (MTD) is calculated using the New Jersey Water Quality Design Storm (1.25 inches in 2 hrs) in N.J.A.C. 7:8-5.5.

2. The HydroDome shall be installed using the same configuration reviewed by NJCAT and shall be sized in accordance with the criteria specified in in item 6 below.

3. This HydroDome cannot be used in series with another MTD or a media filter (such as a sand filter), to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

4. Additional design criteria for MTDs can be found in Chapter 11.3 of the New Jersey Stormwater Best Management Practices (NJ Stormwater BMP) Manual which can be found on-line at www.njstormwater.org.

5. The maintenance plan for a site using this device shall incorporate, at a minimum, the maintenance requirements for the HydroDome, which is attached to this document. However, it is recommended to review the maintenance manual at www.hydroworks.com\hdmaintenance.pdf for any changes to the maintenance requirements.

6. Sizing Requirements:

   The example below demonstrates the sizing procedure for the HydroDome:

   Example: A 0.25-acre impervious site is to be treated to 50% TSS removal using a HydroDome. The impervious site runoff (Q) based on the New Jersey Water Quality Design Storm was determined to be 0.79 cfs.

   Maximum Treatment Flow Rate (MTFR) Evaluation:

   The site runoff (Q) was based on the following:

   time of concentration = 10 minutes
   i=3.2 in/hr (page 21, Fig. 5-10 of Chapter 5 of the NJ Stormwater BMP Manual)
   c=0.99 (curve number for impervious)
   Q=ciA=0.99x3.2x0.25=0.79 cfs

   Given the site runoff is 0.79 cfs and based on Table 1 below, the HydroDome Model HD 3 with a MTFR of 0.85 cfs would be the smallest model approved that could be used for this site that could remove 50% of the TSS from the impervious area without exceeding the MTFR.

   The sizing table corresponding to the available system models is noted below. Additional specifications regarding each model can be found in the Verification Appendix under Table A-1 and Table A-2.

Table 1 HydroDome Models

HydroDome Model	Manhole Diameter (ft)	Maximum Treatment Flowrate, MTFR (cfs)
HD 3	3	0.85
HD 4	4	1.51
HD 5	5	2.36
HD 6	6	3.40
HD 7	7	4.63
HD 8	8	6.03
HD 10	10	9.44
HD 12	12	13.60

Be advised a detailed maintenance plan is mandatory for any project with a Stormwater BMP subject to the Stormwater Management Rules, N.J.A.C. 7:8. The plan must include all the items identified in the Stormwater Management Rules, N.J.A.C. 7:8-5.8. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel. Additional information can be found in Chapter 8: Maintenance and Retrofit of Stormwater Management Measures.

If you have any questions regarding the above information, please contact Lisa Schaefer of my office at lisa.schaefer@dep.nj.gov.

Sincerely,

Gabriel Mahon

Gabriel Mahon, Chief
Bureau of NJPDES Stormwater Permitting & Water Quality Management
Division of Watershed Protection and Restoration
New Jersey Department of Environmental Protection

Attachment: Maintenance Plan

cc: Richard Magee, NJCAT

State of New Jersey

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Mail Code – 401-02B
Division of Water Quality
Bureau of Nonpoint Pollution Control
P.O. Box 420 – 401 E. State St.
Trenton, NJ 08625-0420
Phone: (609) 633-7021 / Fax: (609) 777-0432
http://www.state.nj.us/dep/dwq/bnpc_home.htm

CATHERINE R. McCABE
Acting Commissioner

March 27, 2018

Graham Bryant, M.Sc., P.E.
President
Hydroworks, LLC
136 Central Avenue
Clark, NJ 07066

Re: MTD Lab Certification
HydroStorm Hydrodynamic Separator by Hydroworks, LLC
Online Installation

TSS Removal Rate 50%

Dear Mr. Bryant:

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7 (c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). Hydroworks, LLC has requested an MTD Laboratory Certification for the Hydroworks HydroStorm Hydrodynamic Separator.

The project falls under the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advance Technology" dated January 25, 2013. The applicable protocol is the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" dated January 25, 2013.

NJCAT verification documents submitted to the NJDEP indicate that the requirements of the aforementioned protocol have been met or exceeded. The NJCAT letter also included a recommended certification TSS removal rate and the required maintenance plan. The NJCAT Verification Report with the Verification Appendix (dated February 2018) for this device is published online at http://www.njcat.org/verification-process/technology-verification-database.html.

The NJDEP certifies the use of the HydroStorm by Hydroworks, LLC at a TSS removal rate of 50% when designed, operated, and maintained in accordance with the information provided in the Verification Appendix and the following conditions:

1. The maximum treatment flow rate (MTFR) for the manufactured treatment device (MTD) is calculated using the New Jersey Water Quality Design Storm (1.25 inches in 2 hrs) in N.J.A.C. 7:8-5.5.

2. The HydroStorm shall be installed using the same configuration reviewed by NJCAT and shall be sized in accordance with the criteria specified in item 6 below.

3. This HydroStorm cannot be used in series with another MTD or a media filter (such as a sand filter) to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

4. Additional design criteria for MTDs can be found in Chapter 9.6 of the New Jersey Stormwater Best Management Practices (NJ Stormwater BMP) Manual, which can be found online at www.njstormwater.org.

5. The maintenance plan for a site using this device shall incorporate, at a minimum, the maintenance requirements for the Hydrostorm. A copy of the maintenance plan is attached to this certification. However, it is recommended to review the maintenance website at http://www.hydroworks.com/hydrostormo&m.pdf for any changes to the maintenance requirements.

6. Sizing Requirement:

   The example below demonstrates the sizing procedure for the Hydrostorm:

   Example: A 0.25-acre impervious site is to be treated to 50% TSS removal using a HydroStorm. The impervious site runoff (Q) based on the New Jersey Water Quality Design Storm was determined to be 0.79 cfs.

   Maximum Treatment Flow Rate (MTFR) Evaluation:

   The site runoff (Q) was based on the following:
   time of concentration = 10 minutes
   i = 3.2 in/hr (page 5-8, Fig. 5-3 of the NJ Stormwater BMP Manual)
   c = 0.99 (runoff coefficient for impervious)
   Q = ciA = 0.99 x 3.2 x 0.25 = 0.79 cfs

   Given the site runoff is 0.79 cfs and based on Table 1 below, the HydroStorm Model HS4 with a MTFR of 0.88 cfs could be used for this site to remove 50% of the TSS from the impervious area without exceeding the MTFR.

   The sizing table corresponding to the available system models is noted below. Additional specifications regarding each model can be found in the Verification Appendix under Table A-1.

Table 1 HydroStorm Sizing Information

HydroStorm Model	NJDEP 50% TSS Maximum Treatment Flow Rate (cfs)	Treatment Area (ft^2)	Hydraulic Loading Rate (gpm/ft^2)	50% Maximum Sediment Storage (ft^3)
HS3	0.50	7.1	31.4	3.6
HS4	0.88	12.6	31.4	6.3
HS5	1.37	19.6	31.4	9.8
HS6	1.98	28.3	31.4	14.2
HS7	2.69	38.5	31.4	19.3
HS8	3.52	50.3	31.4	25.2
HS9	4.45	63.6	31.4	31.8
HS10	5.49	78.5	31.4	39.3
HS11	6.65	95.0	31.4	47.5
HS12	7.91	113.0	31.4	56.5

A detailed maintenance plan is mandatory for any project with a Stormwater BMP subject to the Stormwater Management Rules, N.J.A.C. 7:8. The plan must include all of the items identified in the Stormwater Management Rules, N.J.A.C. 7:8-5.8. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel. Additional information can be found in Chapter 8: Maintenance and Retrofit of Stormwater Management Measures.

If you have any questions regarding the above information, please contact Brian Salvo or Nick Grotts of my office at (609) 633-7021.

Sincerely,

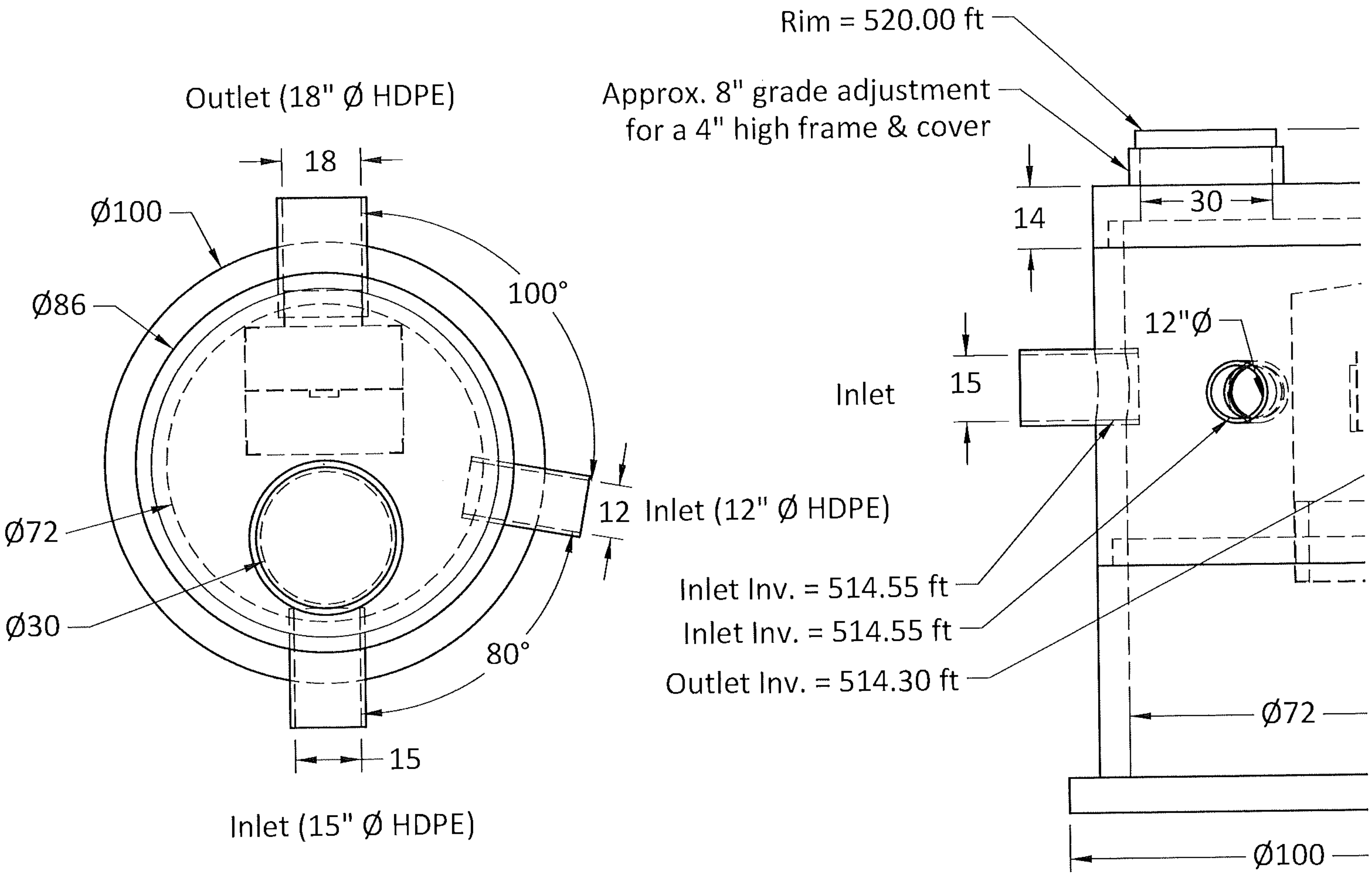
James J. Murphy, Chief
Bureau of Nonpoint Pollution Control

Attachment: Maintenance Plan

cc: Chron File
Richard Magee, NJCAT
Vince Mazzei, NJDEP - DLUR
Ravi Patraju, NJDEP - BES
Gabriel Mahon, NJDEP - BNPC
Brian Salvo, NJDEP – BNPC
Nick Grotts, NJDEP – BNPC

APPENDIX 2

CAD Drawings

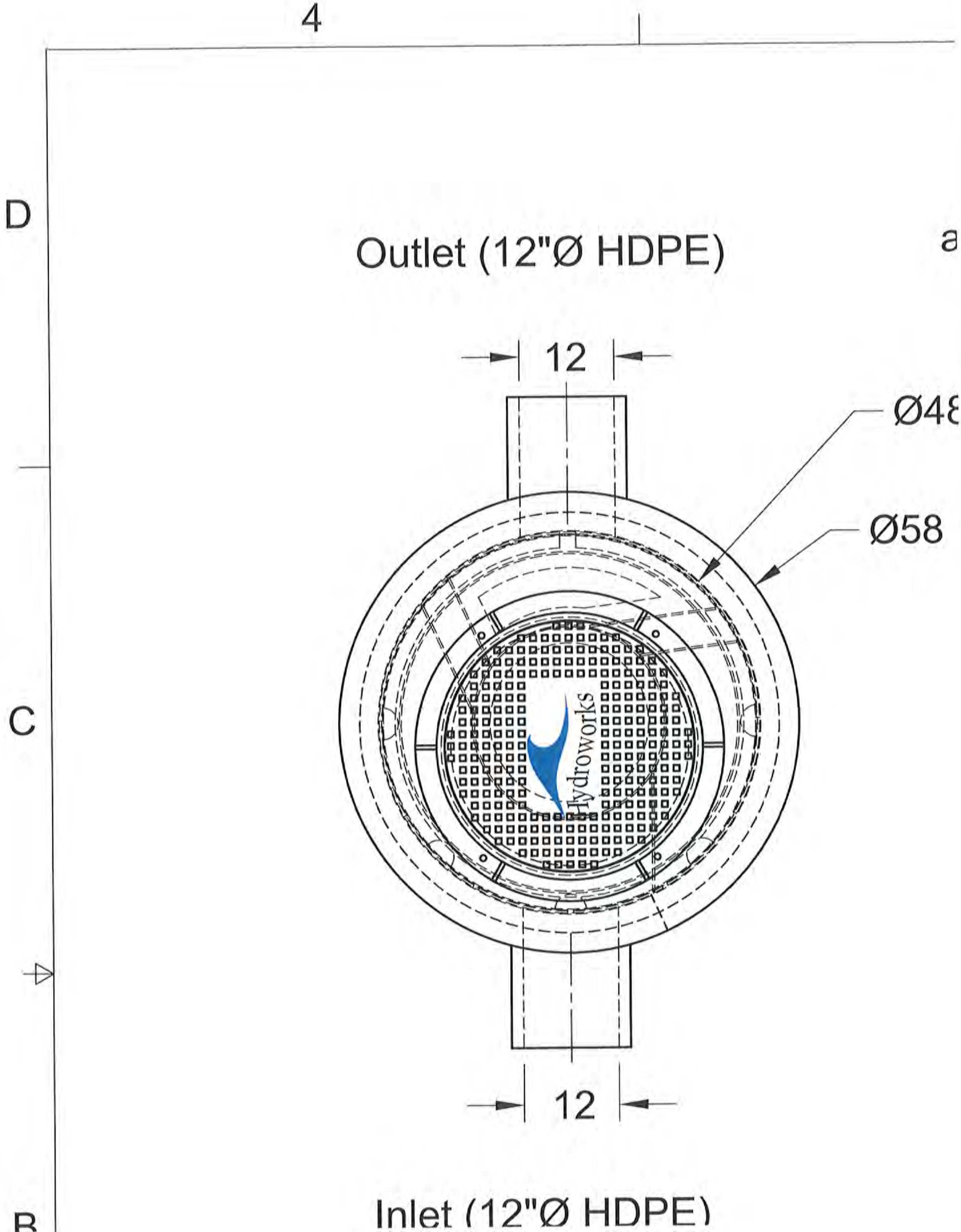


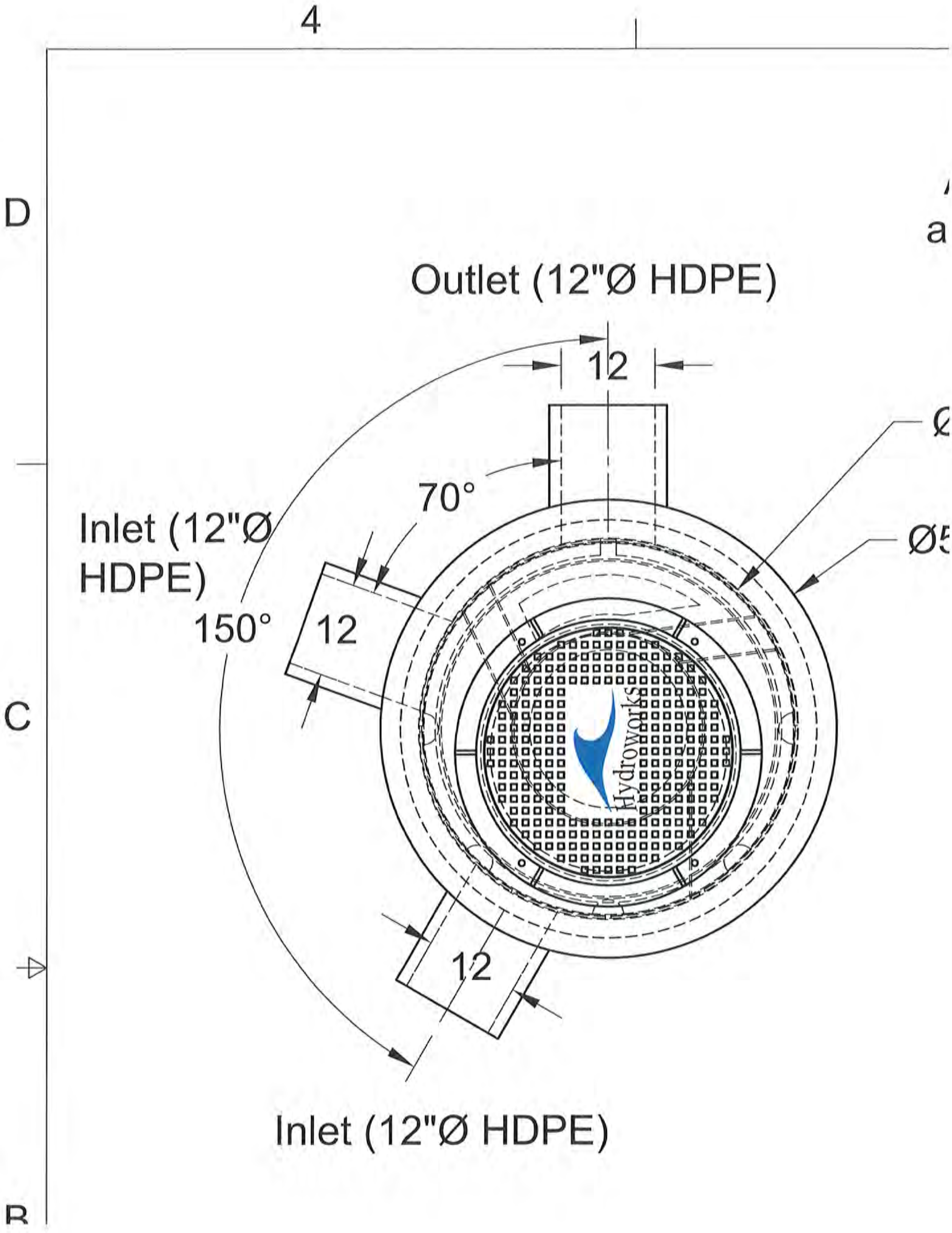
PLAN

PROFILI

Independently tested & independently verified by NJCAT and ETV Canada
NJDEP Certified
US Patent # 10,801,196
CDN Patent # 3,086,197

HydroDome HD 6		
Project Northeast Great Dane HD 1		
Location Sutton, MA		
Date 12/19/2023	SCALE 1:40	REV 1.0


4
D
C
B
Outlet (12"Ø HDPE)
12
Ø48
Ø58
Hydroworks
12
Inlet (12"Ø HDPE)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Outlet (12"Ø HDPE)
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Inlet (12"Ø HDPE)
150°
12
Ø5
a
Hydroworks
12
Inlet (12"Ø HDPE)

APPENDIX 3

HydroDome Sizing Output

Hydroworks

Hydroworks Sizing Summary

Northeast Great Dane HD 1

Sutton, MA

12-19-2023

Recommended Size: HydroDome HD 6

A HydroDome HD 6 is recommended to provide 80 % annual TSS removal based on a drainage area of 4.79 (ac) with an imperviousness of 68 % and Worcester Wso Ap, Massachusetts rainfall for the NJDEP particle size distribution.

The recommended HydroDome HD 6 treats 100 % of the annual runoff and provides 80 % annual TSS removal for the Worcester Wso Ap rainfall records and NJDEP particle size distribution.

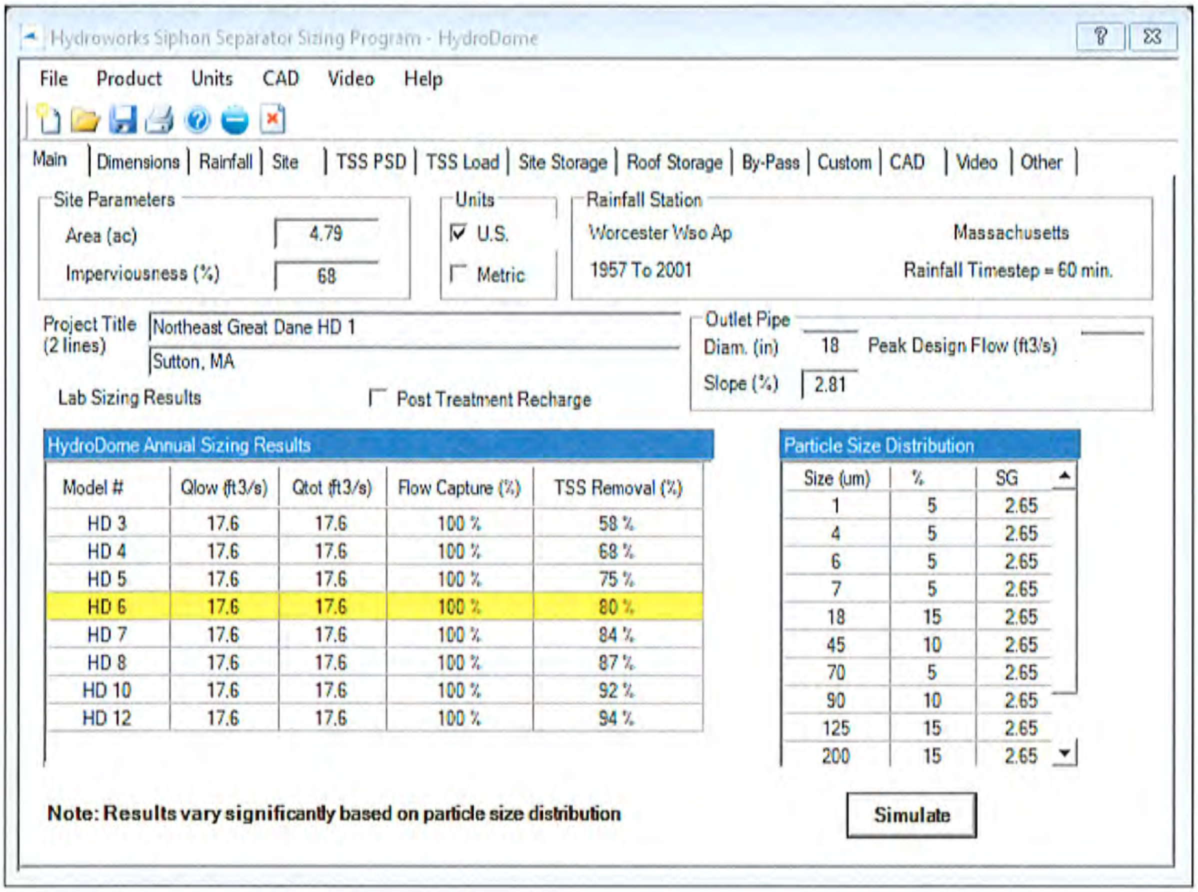
The HydroDome has a siphon which creates a discontinuity in headloss. Since a peak flow was not specified, headloss was calculated using the full pipe flow of 17.61 (ft3/s) for the given 18 (in) pipe diameter at 2.8% slope. The headloss was calculated to be 19 (in) above the crown of the 18 (in) outlet pipe.

This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.

If you have any questions regarding this sizing summary please do not hesitate to contact Hydroworks at 888-290-7900 or email us at support@hydroworks.com.

The sizing program is for sizing purposes only and does not address any site specific parameters such as hydraulic gradeline, tailwater submergence, groundwater, soils bearing capacity, etc. Headloss calculations are not a hydraulic gradeline calculation since this requires a starting water level and an analysis of the entire system downstream of the HydroDome .

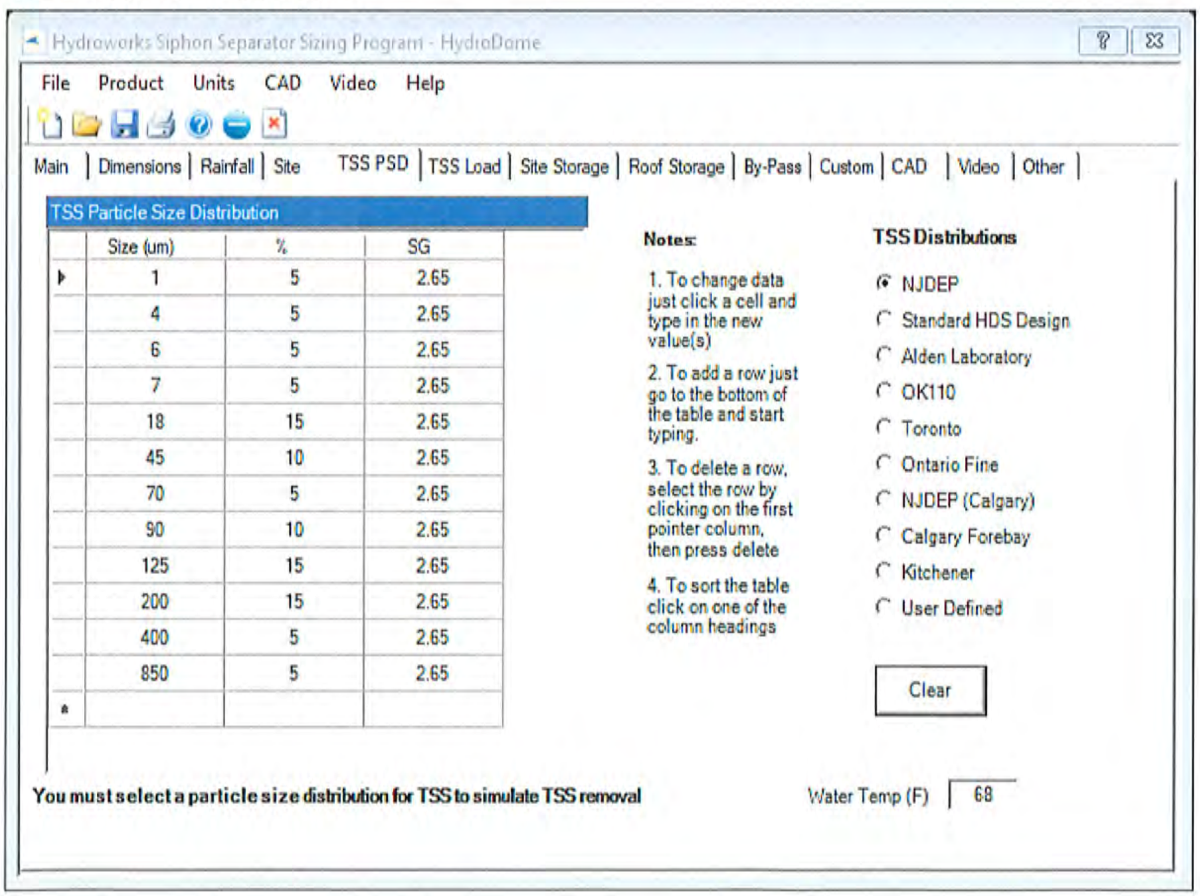
TSS Removal Sizing Summary



Model #	Qlow (ft3/s)	Qtot (ft3/s)	Flow Capture (%)	TSS Removal (%)
HD 3	17.6	17.6	100 %	58 %
HD 4	17.6	17.6	100 %	68 %
HD 5	17.6	17.6	100 %	75 %
HD 6	17.6	17.6	100 %	80 %
HD 7	17.6	17.6	100 %	84 %
HD 8	17.6	17.6	100 %	87 %
HD 10	17.6	17.6	100 %	92 %
HD 12	17.6	17.6	100 %	94 %

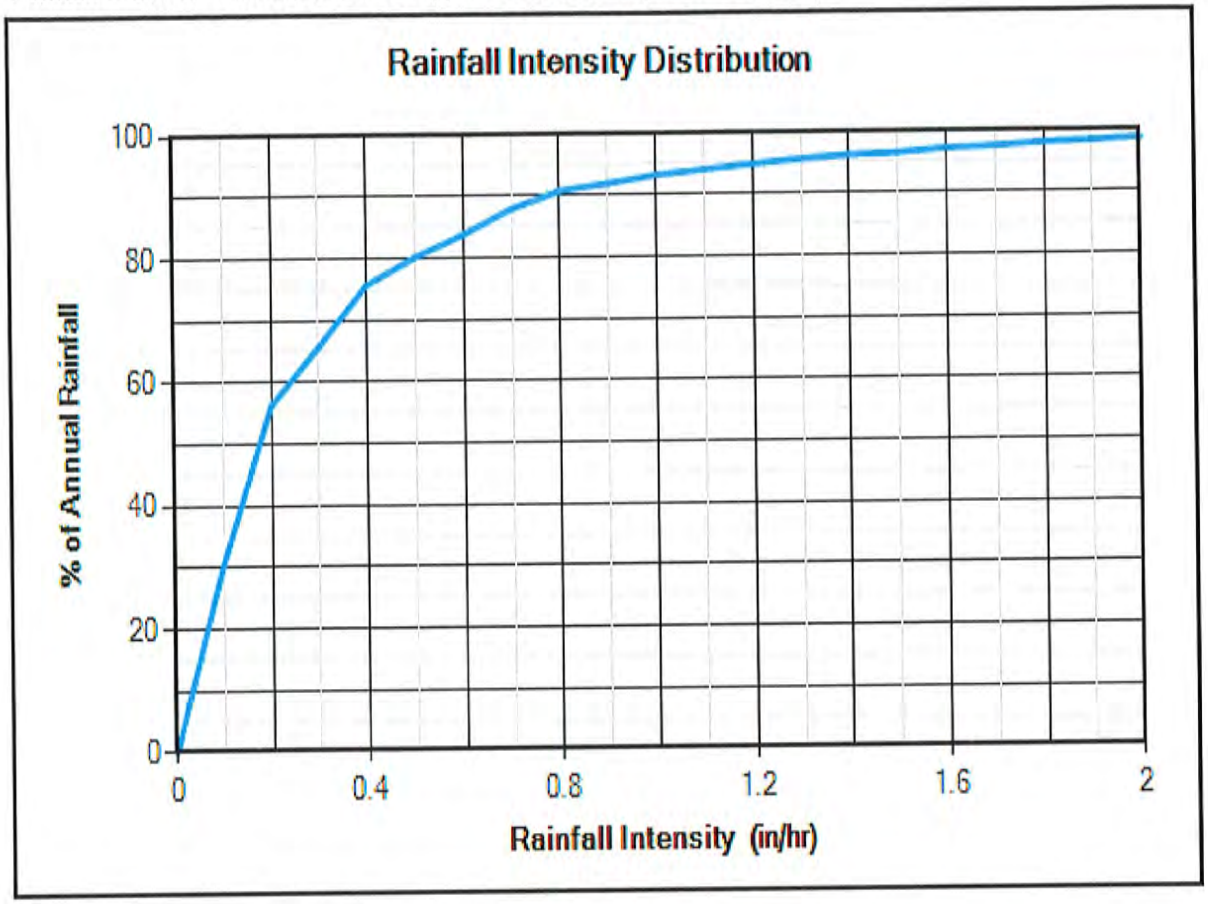
Size (um)	%	SG
1	5	2.65
4	5	2.65
6	5	2.65
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65

TSS Particle Size Distribution

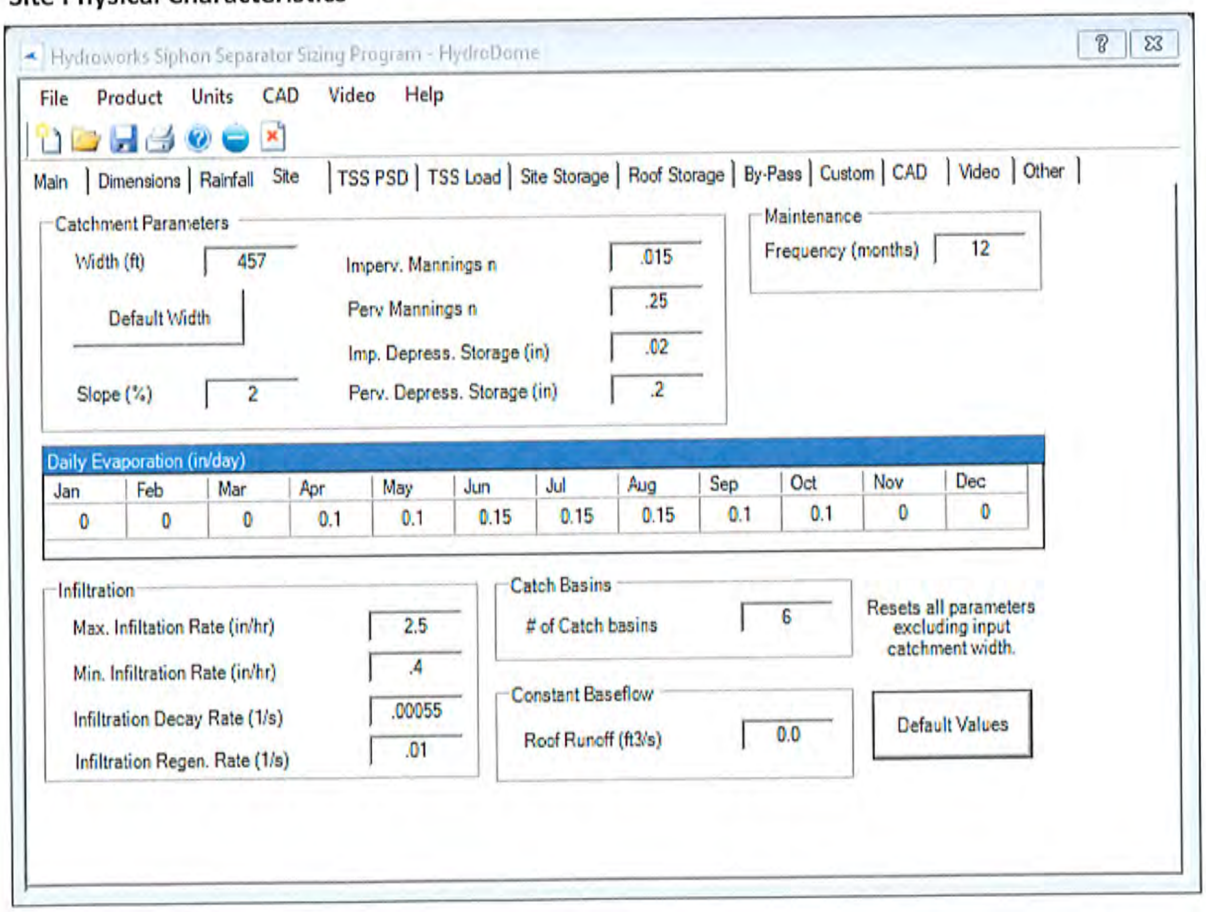


Size (um)	%	SG
1	5	2.65
4	5	2.65
6	5	2.65
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65
400	5	2.65
850	5	2.65

Rainfall Station - Worcester Wso Ap, Massachusetts(1957 To 2001)



Site Physical Characteristics



Dimensions And Capacities

Hydroworks Siphon Separator Sizing Program - HydroDome

File Product Units CAD Video Help

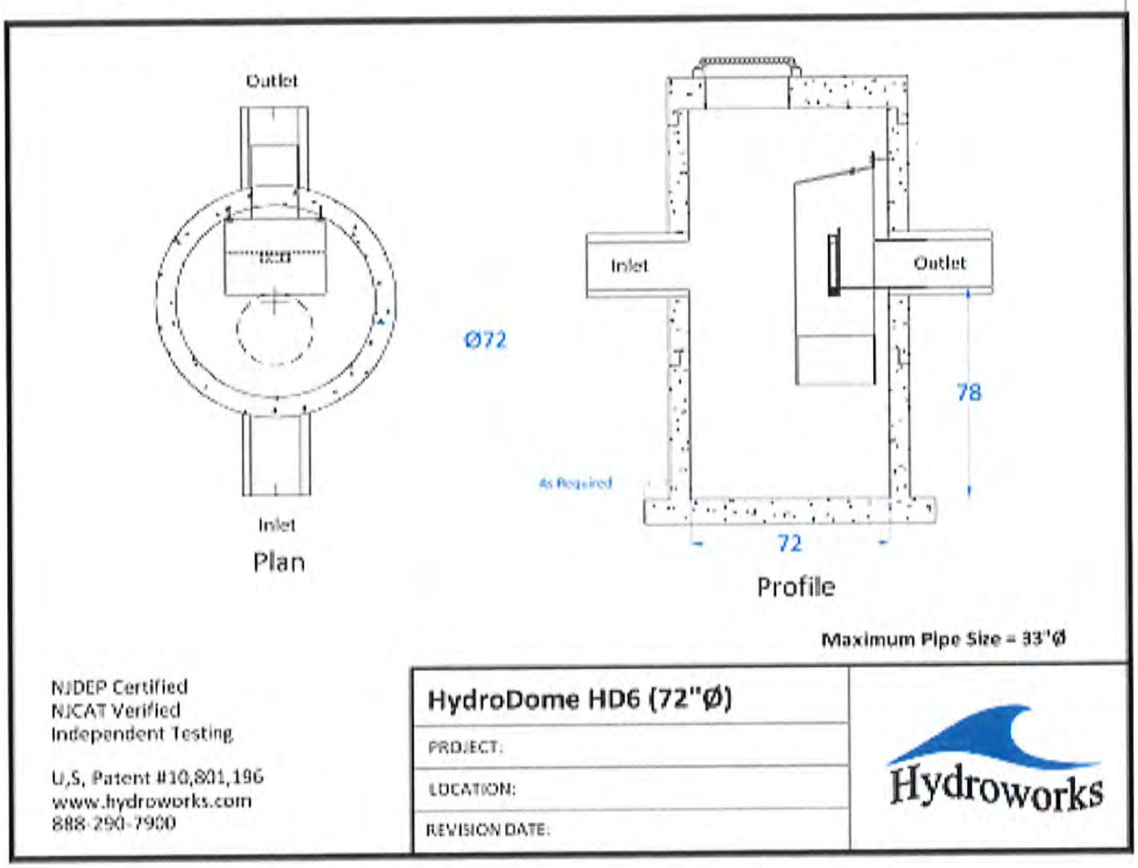
Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

Dimensions and Capacities

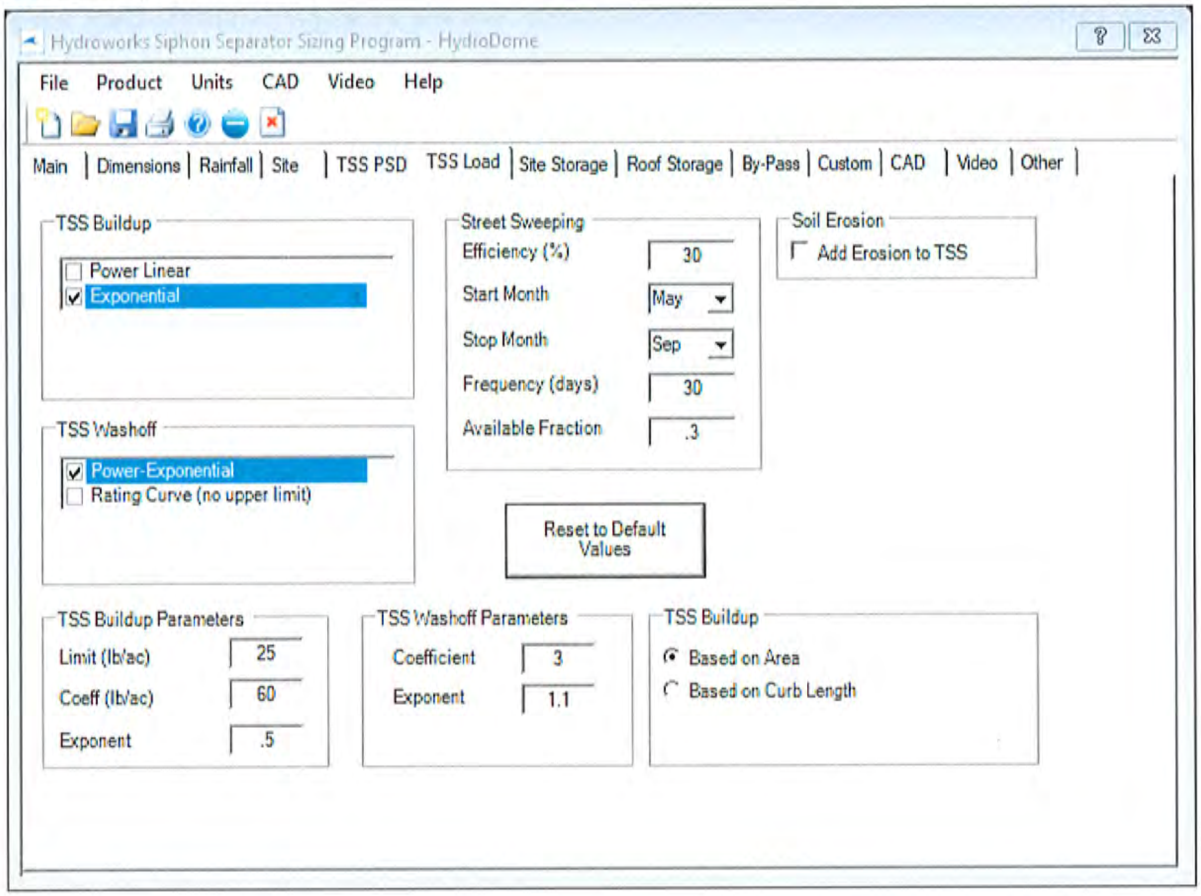
Model	Diam. (ft)	Depth (ft)	Float. Vol. (gal)	Sediment Vol. (ft3)	Total Vol. (gal)
HD 3	3	4	33	17	212
HD 4	4	4.5	70	31	423
HD 5	5	5.5	128	61	808
HD 6	6	6.5	212	104	1375
HD 7	7	7.5	324	164	2159
HD 8	8	8.5	492	239	3196
HD 10	10	10.5	955	458	6169
HD 12	12	12.5	1644	782	10575

Depth = Depth from outlet invert to inside bottom of tank

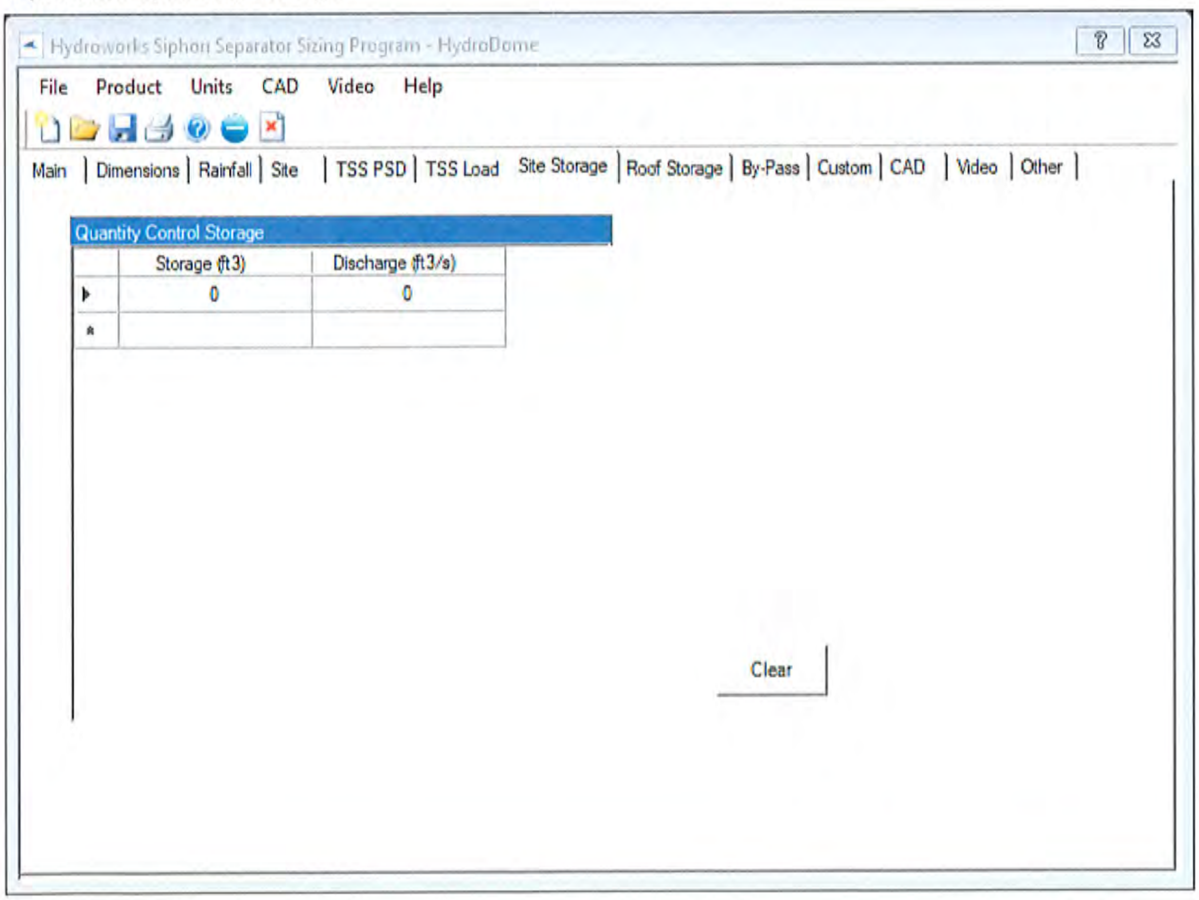
Generic HD 6 CAD Drawing



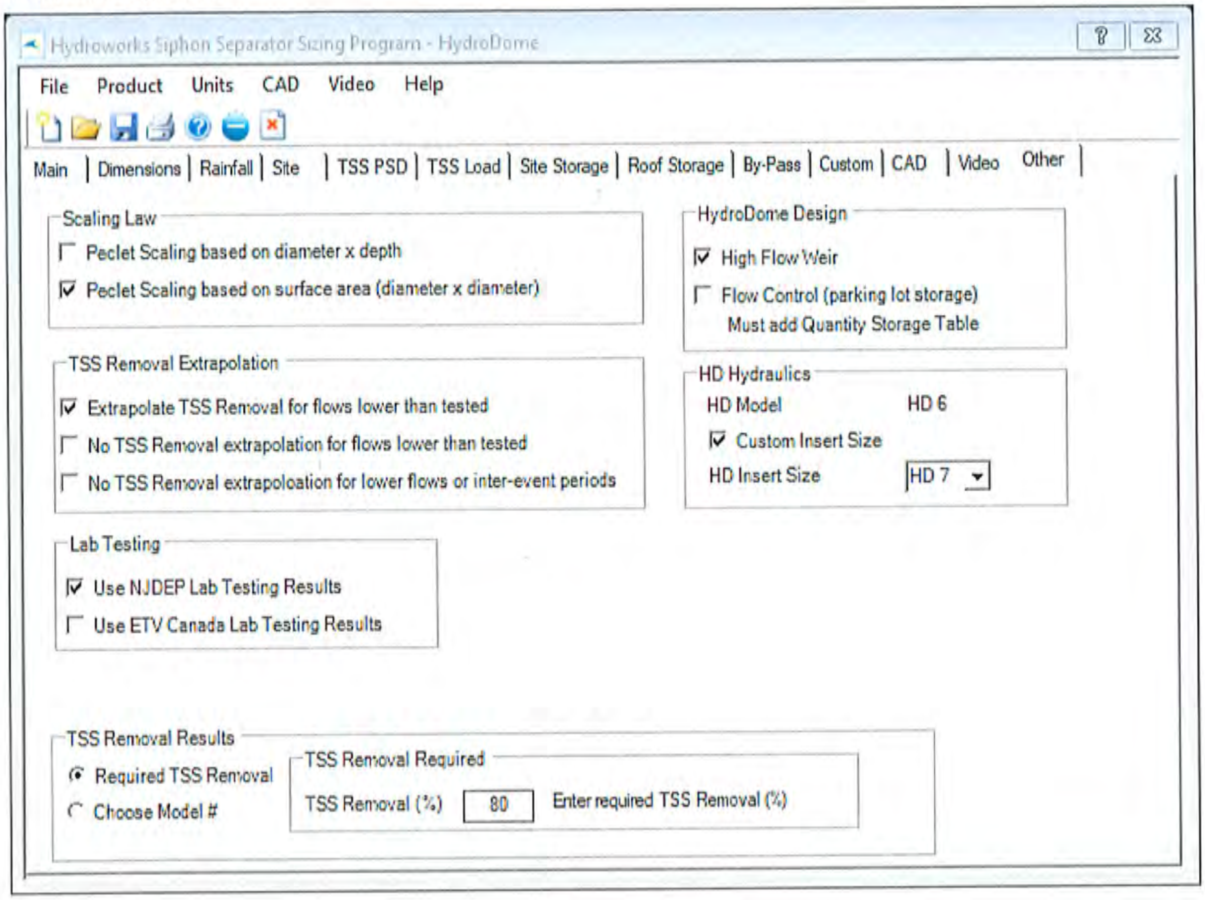
TSS Buildup And Washoff



Upstream Quantity Storage



Other Parameters



Flagged Issues

If there is underground detention storage upstream of the HydroDome please contact Hydroworks to ensure it has been modeled correctly.

Hydroworks Sizing Program - Version 5.9

1-800-290-7900
www.hydroworks.com

Hydroworks

Hydroworks Sizing Summary

Northeast Great Dane HD 2
Sutton, MA

12-19-2023

Recommended Size: HydroStorm HS 4

A HydroStorm HS 4 is recommended to provide 80 % annual TSS removal based on a drainage area of 1.13 (ac) with an imperviousness of 27 % and Worcester Wso Ap, Massachusetts rainfall for the NJDEP particle size distribution.

The recommended HydroStorm HS 4 treats 99 % of the annual runoff and provides 81 % annual TSS removal for the Worcester Wso Ap rainfall records and NJDEP particle size distribution.

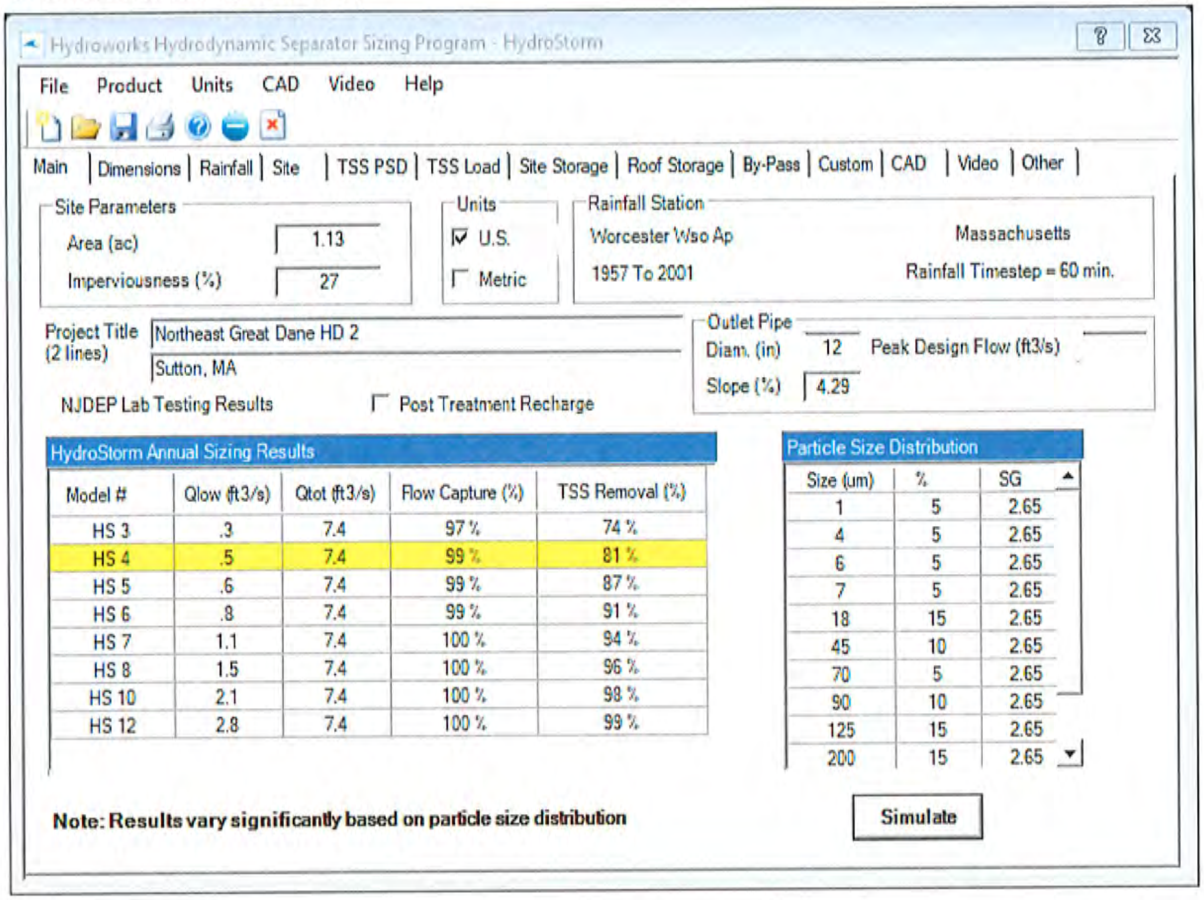
The HydroStorm has a headloss coefficient (K) of 1.04. Since a peak flow was not specified, headloss was calculated using the full pipe flow of 7.38 (ft3/s) for the given 12 (in) pipe diameter at 4.3% slope. The headloss was calculated to be 17 (in) based on a flow depth of 12 (in) (full pipe flow).

This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.

If you have any questions regarding this sizing summary please do not hesitate to contact Hydroworks at 888-290-7900 or email us at support@hydroworks.com.

The sizing program is for sizing purposes only and does not address any site specific parameters such as hydraulic gradeline, tailwater submergence, groundwater, soils bearing capacity, etc. Headloss calculations are not a hydraulic gradeline calculation since this requires a starting water level and an analysis of the entire system downstream of the HydroStorm .

TSS Removal Sizing Summary



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units CAD Video Help

Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

Site Parameters
Area (ac) 1.13
Imperviousness (%) 27

Units
☑ U.S.
☐ Metric

Rainfall Station
Worcester Wso Ap Massachusetts
1957 To 2001 Rainfall Timestep = 60 min.

Project Title (2 lines) Northeast Great Dane HD 2
Sutton, MA

Outlet Pipe
Diam. (in) 12 Peak Design Flow (ft3/s)
Slope (%) 4.29

NJDEP Lab Testing Results ☐ Post Treatment Recharge

HydroStorm Annual Sizing Results

Model #	Qlow (ft3/s)	Qtot (ft3/s)	Flow Capture (%)	TSS Removal (%)
HS 3	.3	7.4	97 %	74 %
HS 4	.5	7.4	99 %	81 %
HS 5	.6	7.4	99 %	87 %
HS 6	.8	7.4	99 %	91 %
HS 7	1.1	7.4	100 %	94 %
HS 8	1.5	7.4	100 %	96 %
HS 10	2.1	7.4	100 %	98 %
HS 12	2.8	7.4	100 %	99 %

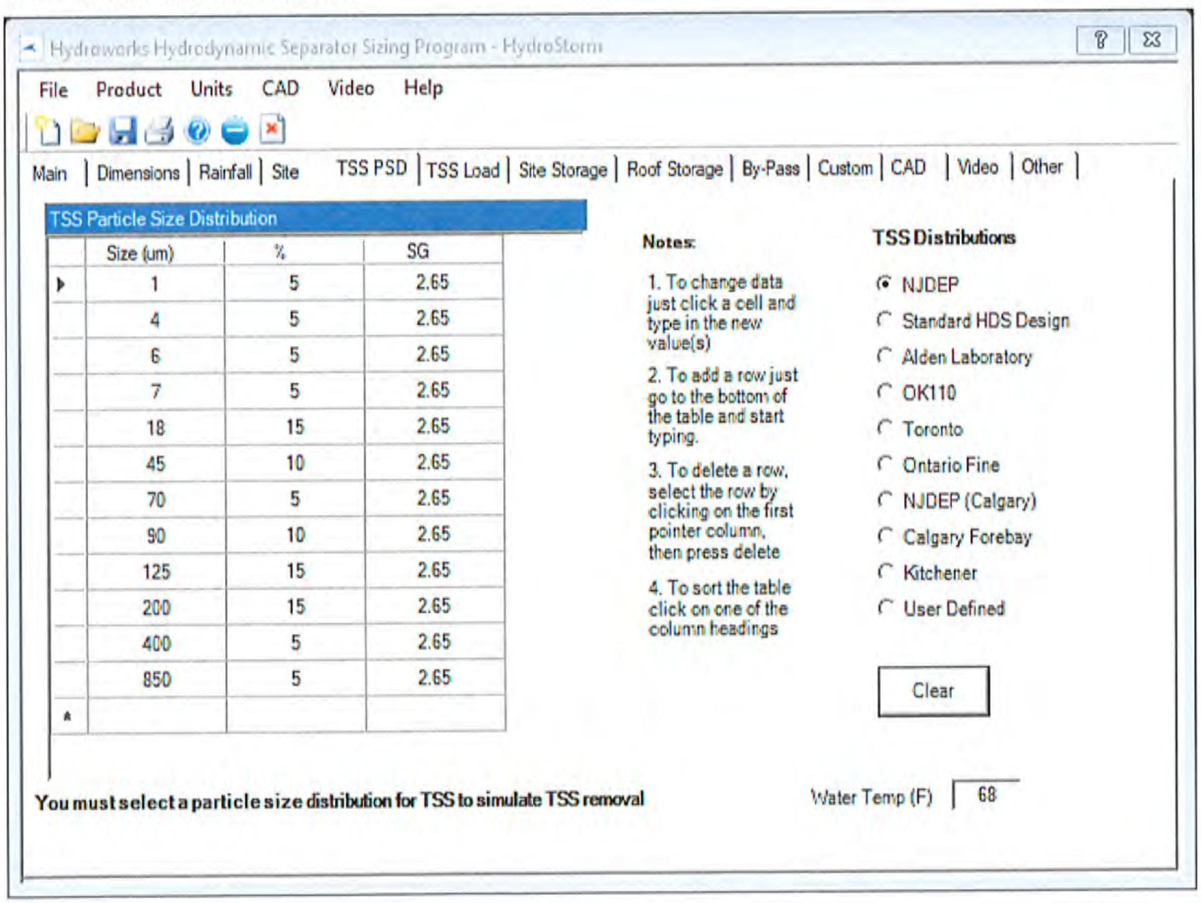
Particle Size Distribution

Size (um)	%	SG
1	5	2.65
4	5	2.65
6	5	2.65
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65

Note: Results vary significantly based on particle size distribution

Simulate

TSS Particle Size Distribution



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units CAD Video Help

Main | Dimensions | Rainfall | Site TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

TSS Particle Size Distribution

	Size (um)	%	SG
▶	1	5	2.65
	4	5	2.65
	6	5	2.65
	7	5	2.65
	18	15	2.65
	45	10	2.65
	70	5	2.65
	90	10	2.65
	125	15	2.65
	200	15	2.65
	400	5	2.65
	850	5	2.65
*			

Notes:

1. To change data just click a cell and type in the new value(s)
2. To add a row just go to the bottom of the table and start typing.
3. To delete a row, select the row by clicking on the first pointer column, then press delete
4. To sort the table click on one of the column headings

TSS Distributions

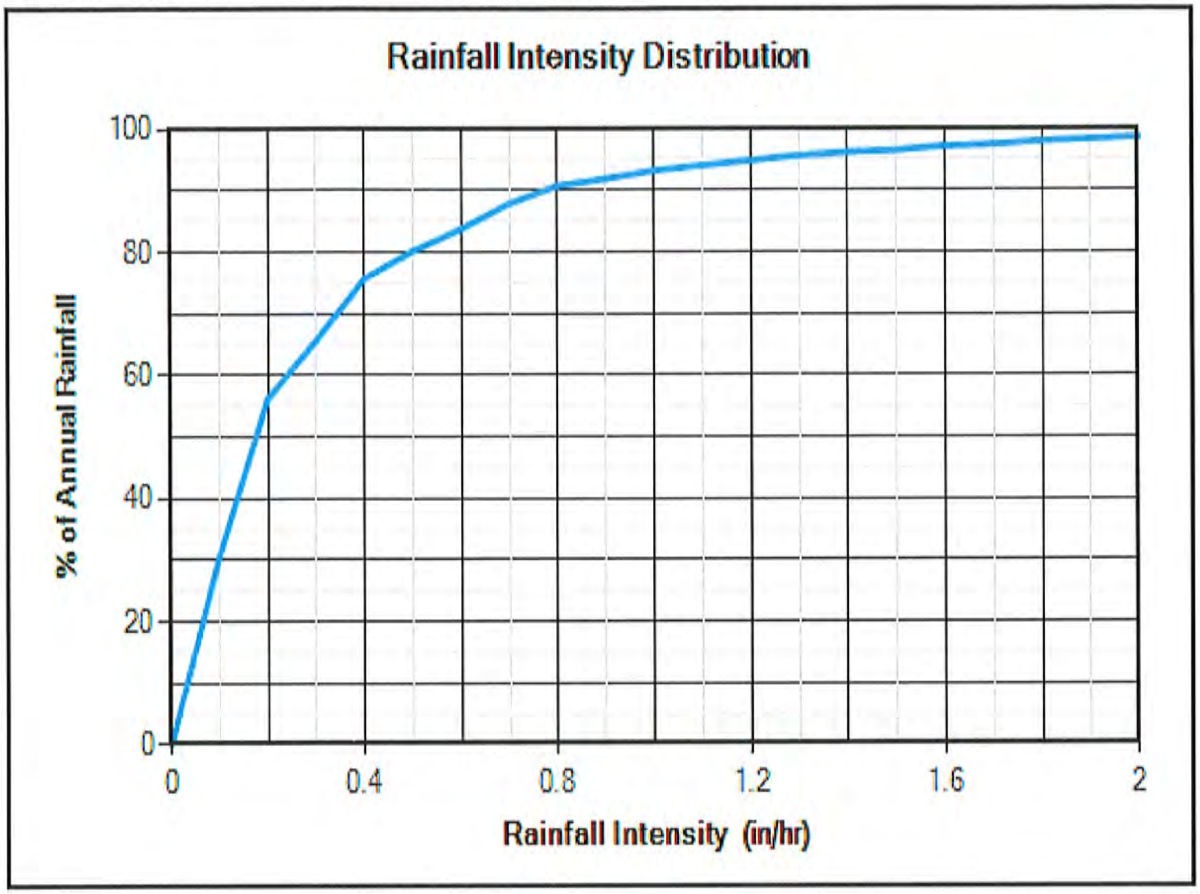
- (•) NJDEP
- ( ) Standard HDS Design
- ( ) Alden Laboratory
- ( ) OK110
- ( ) Toronto
- ( ) Ontario Fine
- ( ) NJDEP (Calgary)
- ( ) Calgary Forebay
- ( ) Kitchener
- ( ) User Defined

Clear

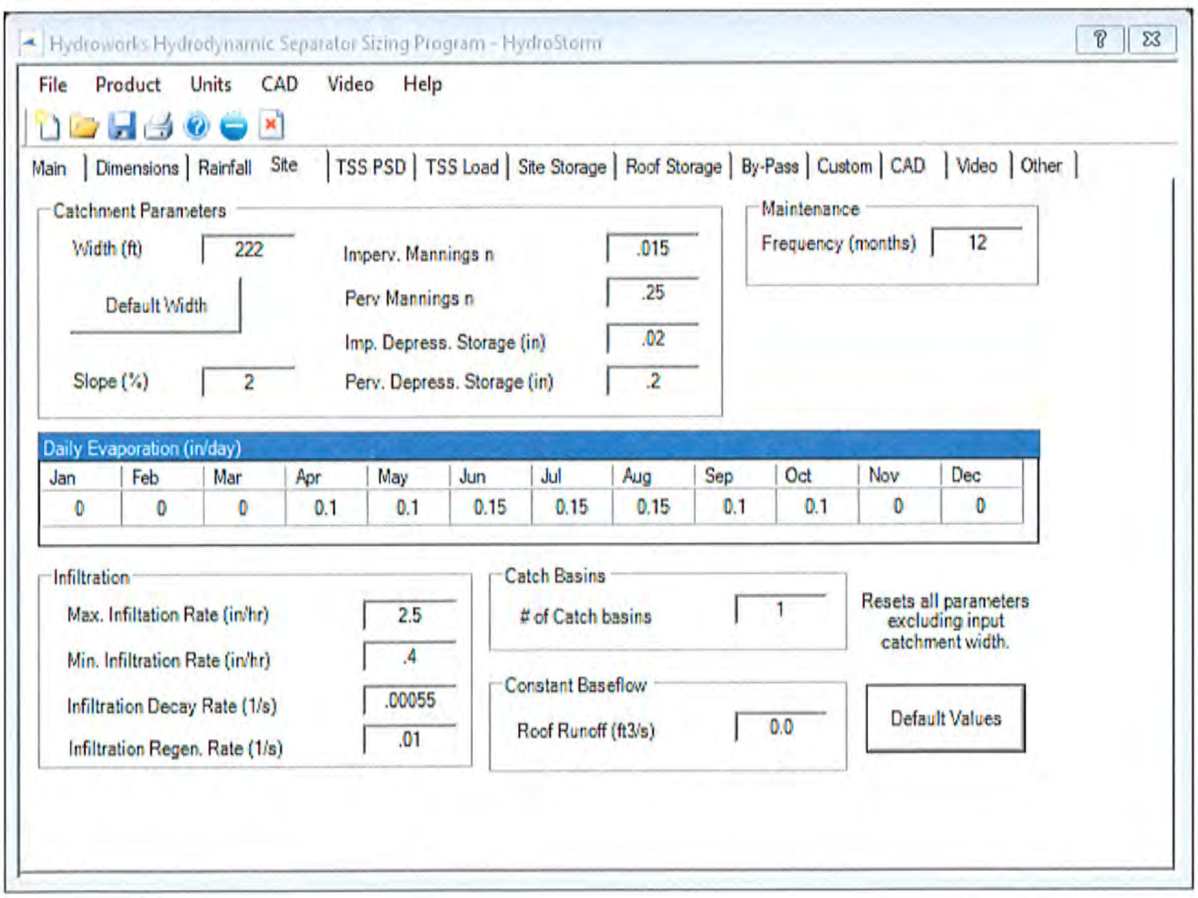
You must select a particle size distribution for TSS to simulate TSS removal

Water Temp (F) 68

Rainfall Station - Worcester Wso Ap, Massachusetts(1957 To 2001)



Site Physical Characteristics



Dimensions And Capacities

Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units CAD Video Help

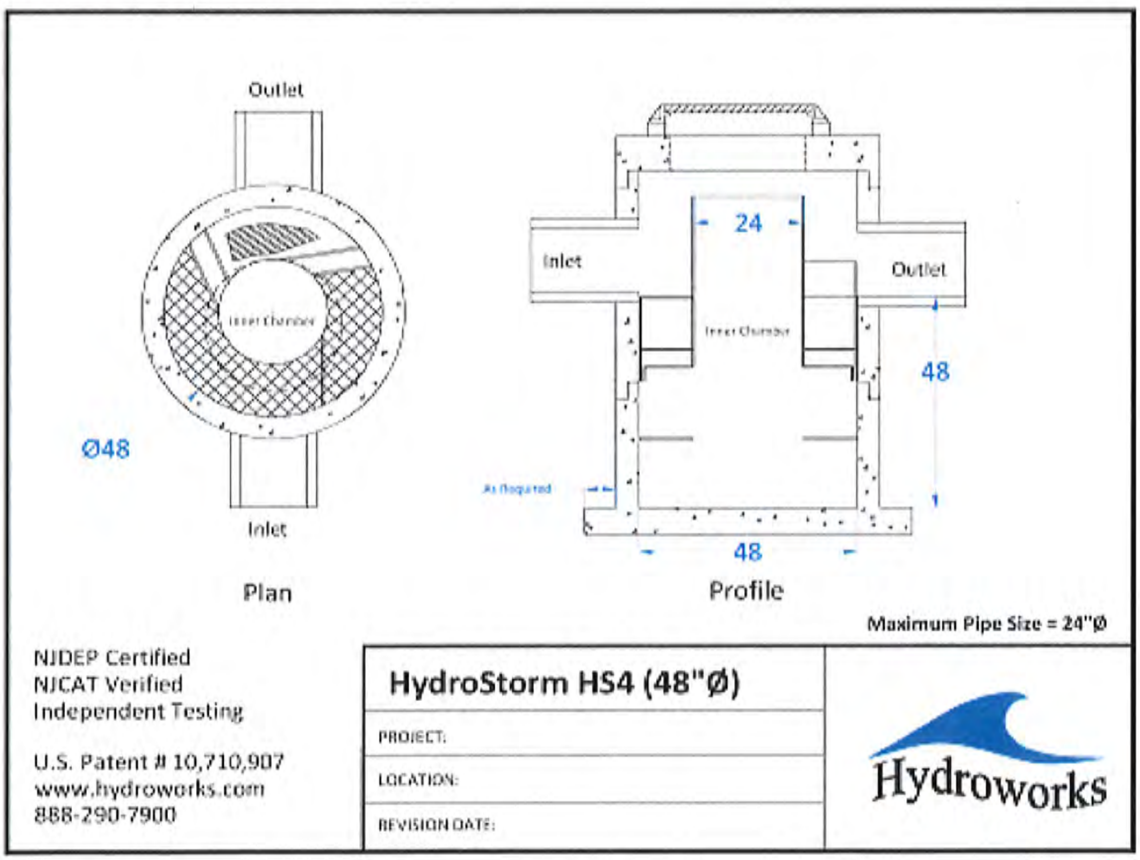
Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

Dimensions and Capacities

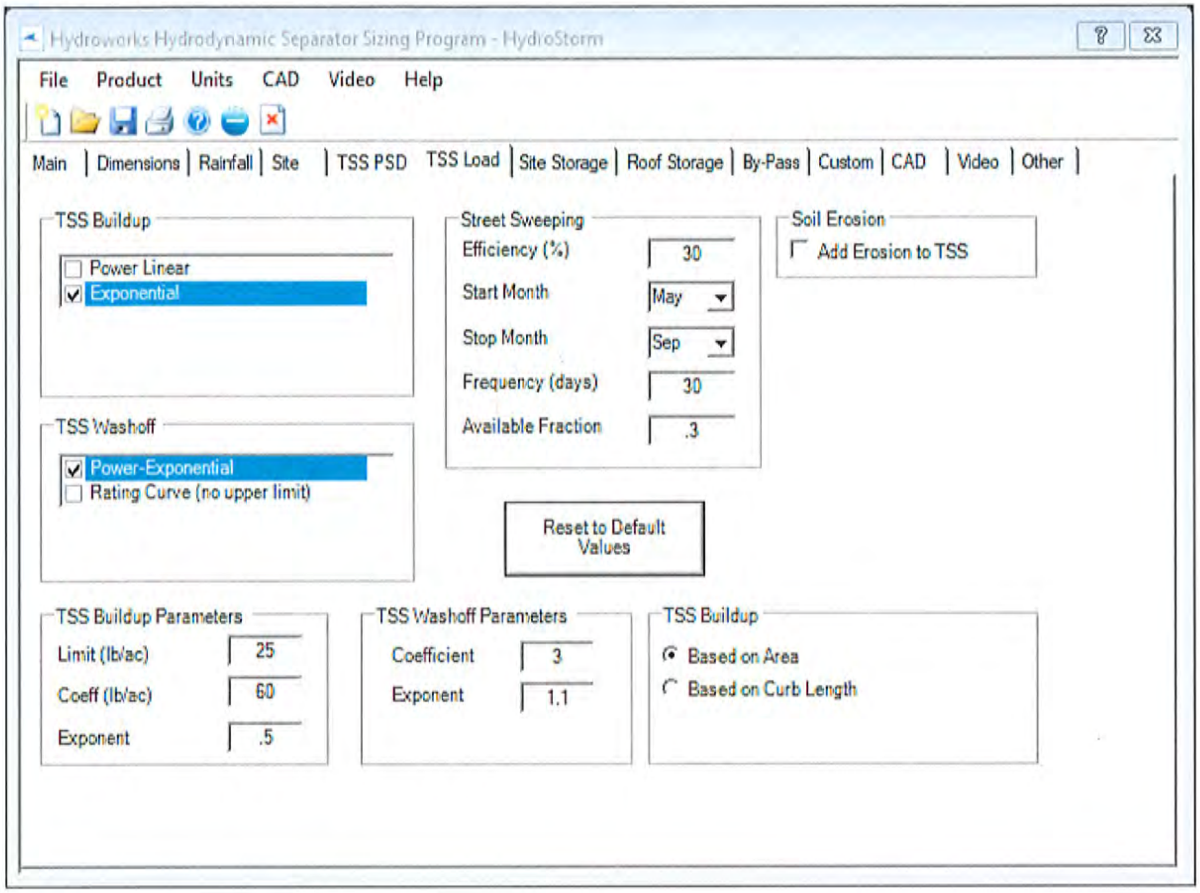
Model	Diam. (ft)	Depth (ft)	Float. Vol. (gal)	Sediment Vol. (ft3)	Total Vol. (gal)
HS 3	3	3.5	49	15	185
HS 4	4	4	101	30	376
HS 5	5	5	170	64	734
HS 6	6	6	275	113	1269
HS 7	7	6.5	416	164	1871
HS 8	8	7	622	222	2632
HS 10	10	9	1143	465	5288
HS 12	12	11	1893	839	9306

Depth = Depth from outlet invert to inside bottom of tank

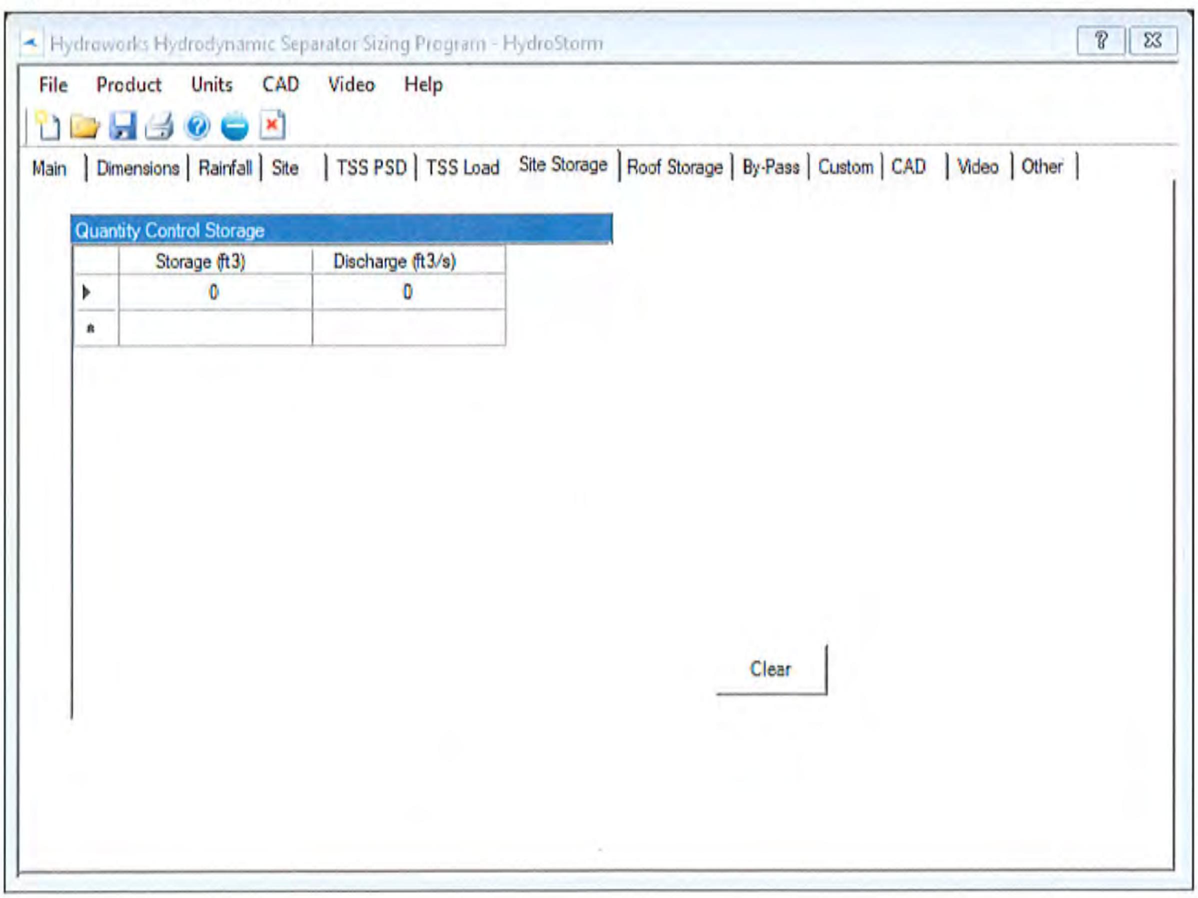
Generic HS 4 CAD Drawing



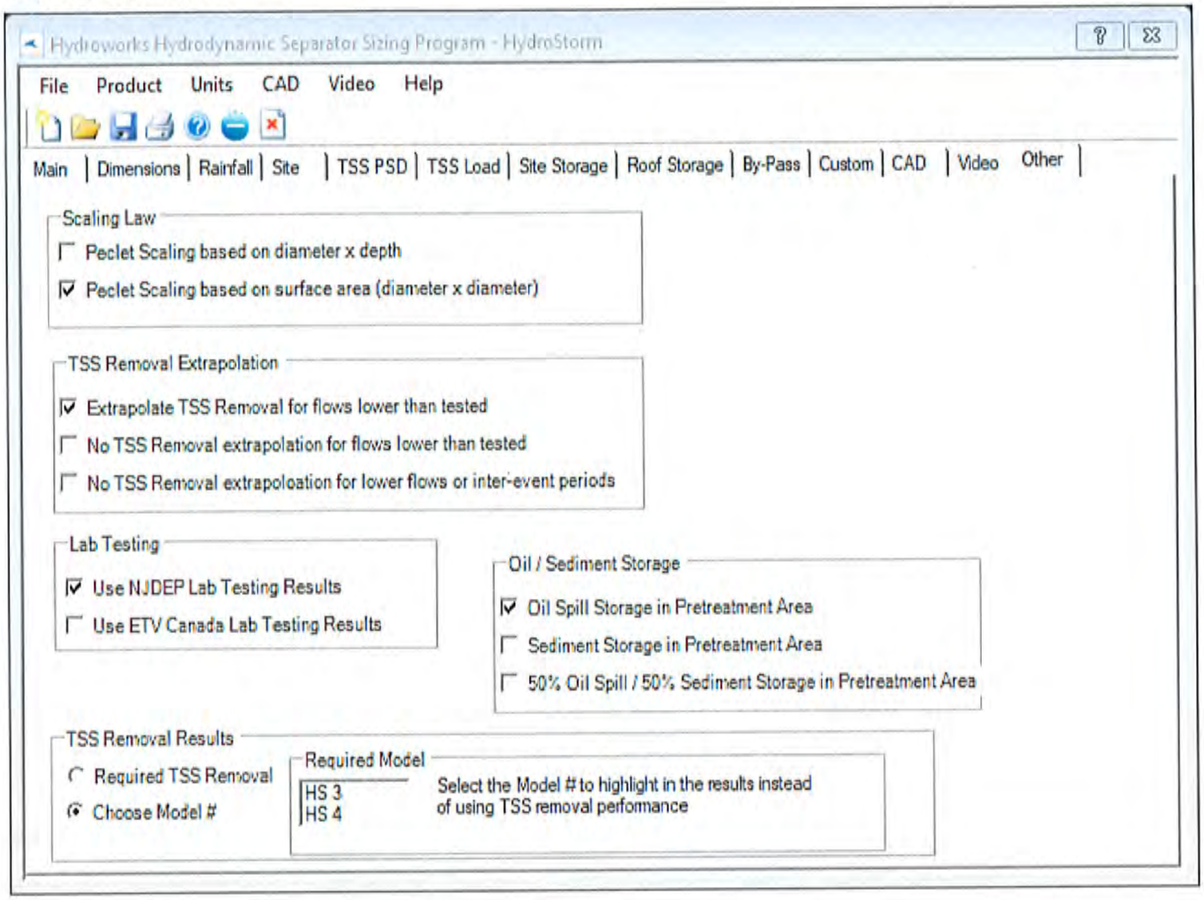
TSS Buildup And Washoff



Upstream Quantity Storage



Other Parameters



Flagged Issues

None

Hydroworks Sizing Program - Version 5.9

1-800-290-7900
www.hydroworks.com

Hydroworks

Hydroworks Sizing Summary

Northeast Great Dane HD 3
Sutton, MA

12-19-2023

Recommended Size: HydroStorm HS 4

A HydroStorm HS 4 is recommended to provide 80 % annual TSS removal based on a drainage area of .67 (ac) with an imperviousness of 65 % and Worcester Wso Ap, Massachusetts rainfall for the NJDEP particle size distribution.

The recommended HydroStorm HS 4 treats 100 % of the annual runoff and provides 80 % annual TSS removal for the Worcester Wso Ap rainfall records and NJDEP particle size distribution.

The HydroStorm has a headloss coefficient (K) of 1.04. Since a peak flow was not specified, headloss was calculated using the full pipe flow of 4.82 (ft3/s) for the given 12 (in) pipe diameter at 1.8% slope. The headloss was calculated to be 7 (in) based on a flow depth of 12 (in) (full pipe flow).

This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.

If you have any questions regarding this sizing summary please do not hesitate to contact Hydroworks at 888-290-7900 or email us at support@hydroworks.com.

The sizing program is for sizing purposes only and does not address any site specific parameters such as hydraulic gradeline, tailwater submergence, groundwater, soils bearing capacity, etc. Headloss calculations are not a hydraulic gradeline calculation since this requires a starting water level and an analysis of the entire system downstream of the HydroStorm .

TSS Removal Sizing Summary

Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File | Product | Units | CAD | Video | Help

Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

Site Parameters

Area (ac) .67

Imperviousness (%) 65

Units

☑ U.S.

☐ Metric

Rainfall Station

Worcester Wso Ap — Massachusetts

1957 To 2001 — Rainfall Timestep = 60 min.

Project Title (2 lines): Northeast Great Dane HD 3 / Sutton, MA

Outlet Pipe

Diam. (in) 12

Slope (%) 1.83

Peak Design Flow (ft3/s)

NJDEP Lab Testing Results

☐ Post Treatment Recharge

HydroStorm Annual Sizing Results

Model #	Qlow (ft3/s)	Qtot (ft3/s)	Flow Capture (%)	TSS Removal (%)
HS 3	.5	4.8	98 %	73 %
HS 4	.9	4.8	100 %	80 %
HS 5	1.2	4.8	100 %	86 %
HS 6	1.4	4.8	100 %	90 %
HS 7	2	4.8	100 %	93 %
HS 8	2.6	4.8	100 %	94 %
HS 10	3.8	4.8	100 %	97 %
HS 12	4.8	4.8	100 %	99 %

Particle Size Distribution

Size (um)	%	SG
1	5	2.65
4	5	2.65
6	5	2.65
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65

Note: Results vary significantly based on particle size distribution

Simulate

TSS Particle Size Distribution

Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File | Product | Units | CAD | Video | Help

Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

TSS Particle Size Distribution

Size (um)	%	SG
1	5	2.65
4	5	2.65
6	5	2.65
7	5	2.65
18	15	2.65
45	10	2.65
70	5	2.65
90	10	2.65
125	15	2.65
200	15	2.65
400	5	2.65
850	5	2.65

Notes:

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- (●) NJDEP
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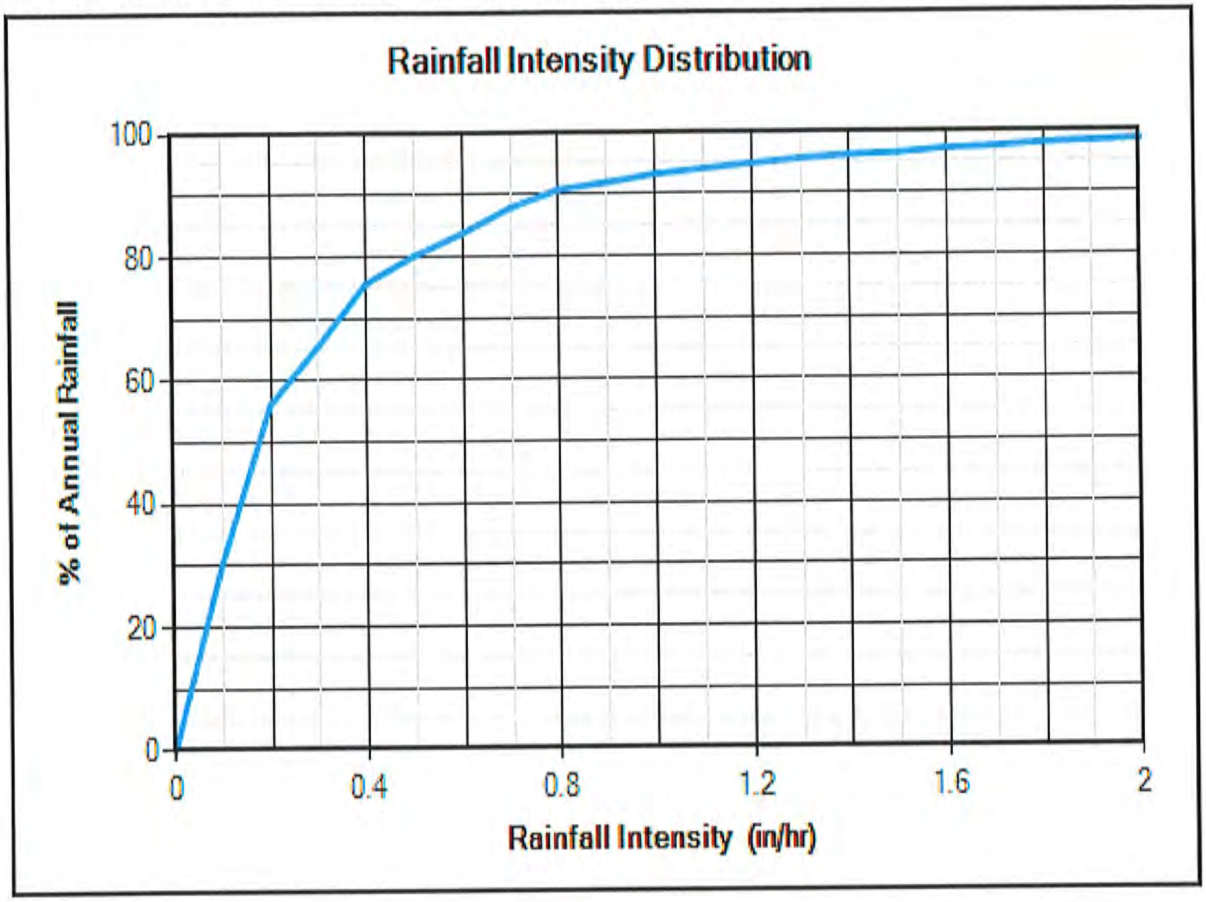
- ( ) Toronto
- ( ) Ontario Fine
- ( ) NJDEP (Calgary)
- ( ) Calgary Forebay
- ( ) Kitchener
- ( ) User Defined

Clear

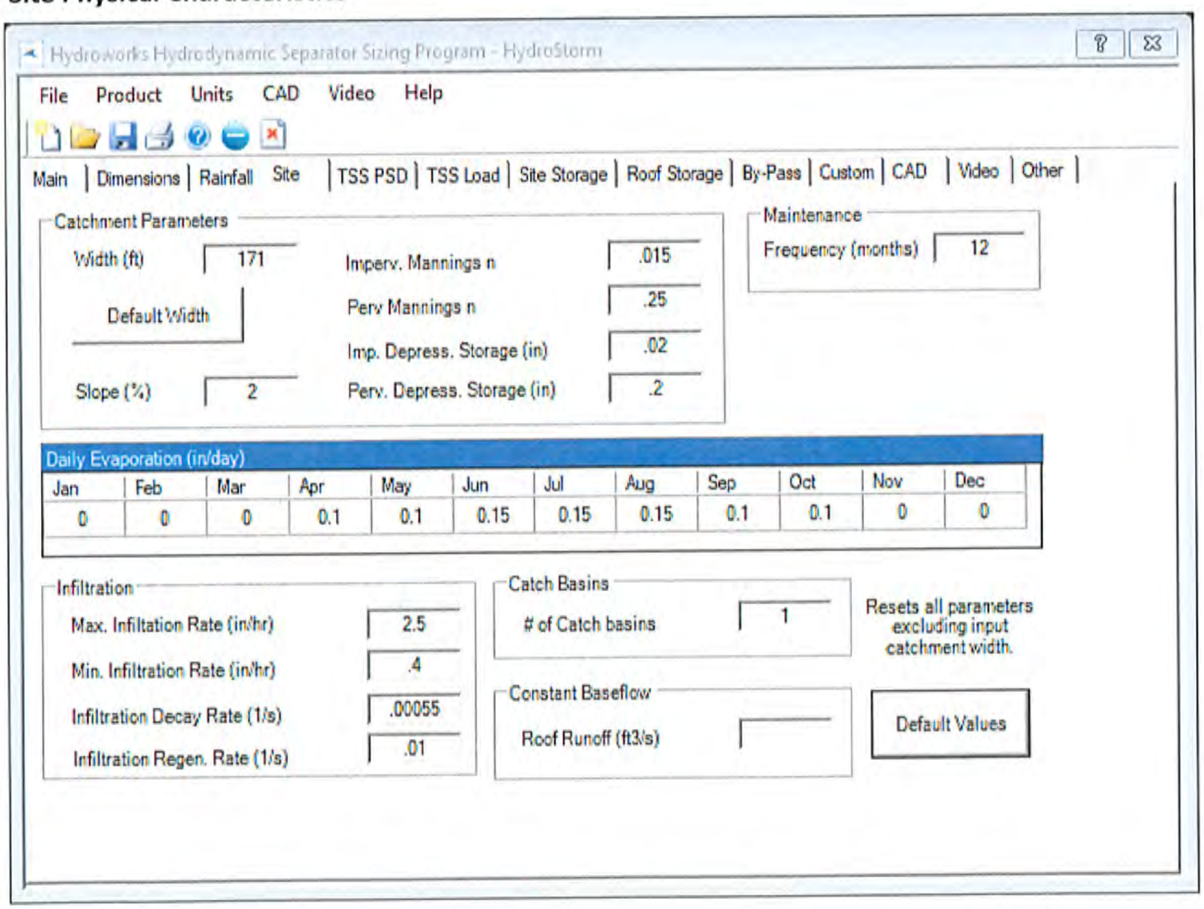
You must select a particle size distribution for TSS to simulate TSS removal

Water Temp (F) 68

Rainfall Station - Worcester Wso Ap, Massachusetts(1957 To 2001)



Site Physical Characteristics



Dimensions And Capacities

Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File | Product | Units | CAD | Video | Help

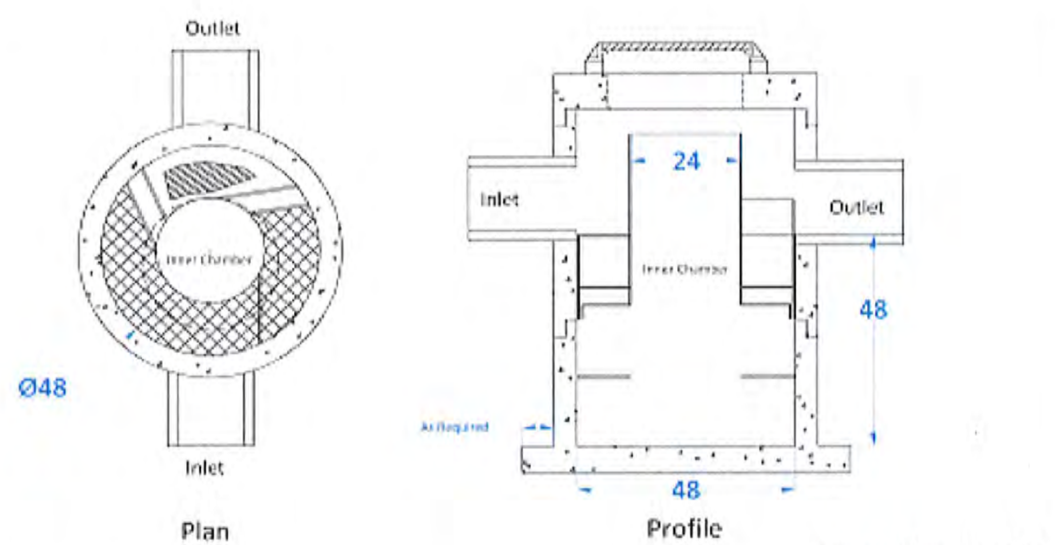
Main | Dimensions | Rainfall | Site | TSS PSD | TSS Load | Site Storage | Roof Storage | By-Pass | Custom | CAD | Video | Other

Dimensions and Capacities

Model	Diam. (ft)	Depth (ft)	Float. Vol. (gal)	Sediment Vol. (ft3)	Total Vol. (gal)
HS 3	3	3.5	49	15	185
HS 4	4	4	101	30	376
HS 5	5	5	170	64	734
HS 6	6	6	275	113	1269
HS 7	7	6.5	416	164	1871
HS 8	8	7	622	222	2632
HS 10	10	9	1143	465	5288
HS 12	12	11	1893	839	9306

Depth = Depth from outlet invert to inside bottom of tank

Generic HS 4 CAD Drawing



Maximum Pipe Size = 24"Ø

NJDEP Certified
NJCAT Verified
Independent Testing

U.S. Patent # 10,710,907
www.hydroworks.com
888-290-7900

HydroStorm HS4 (48"Ø)

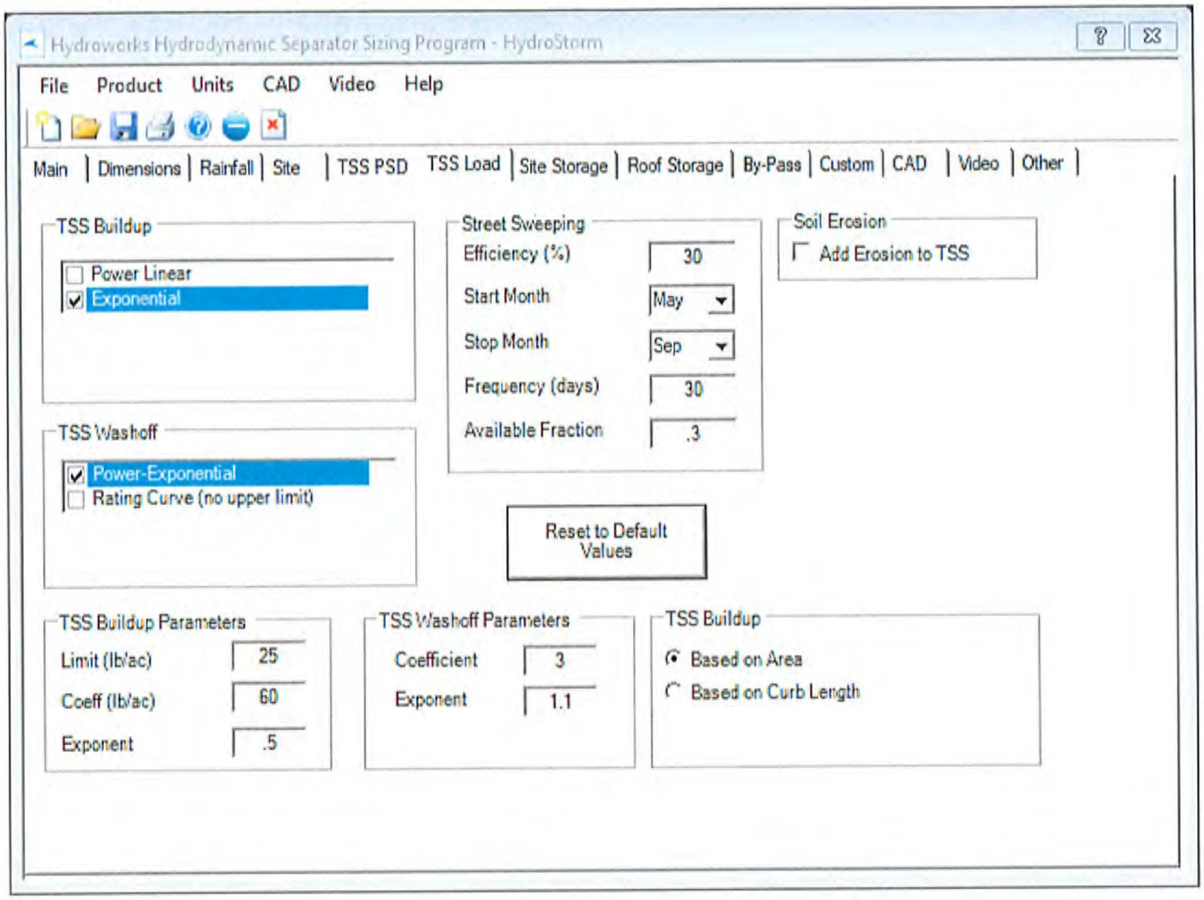
PROJECT:

LOCATION:

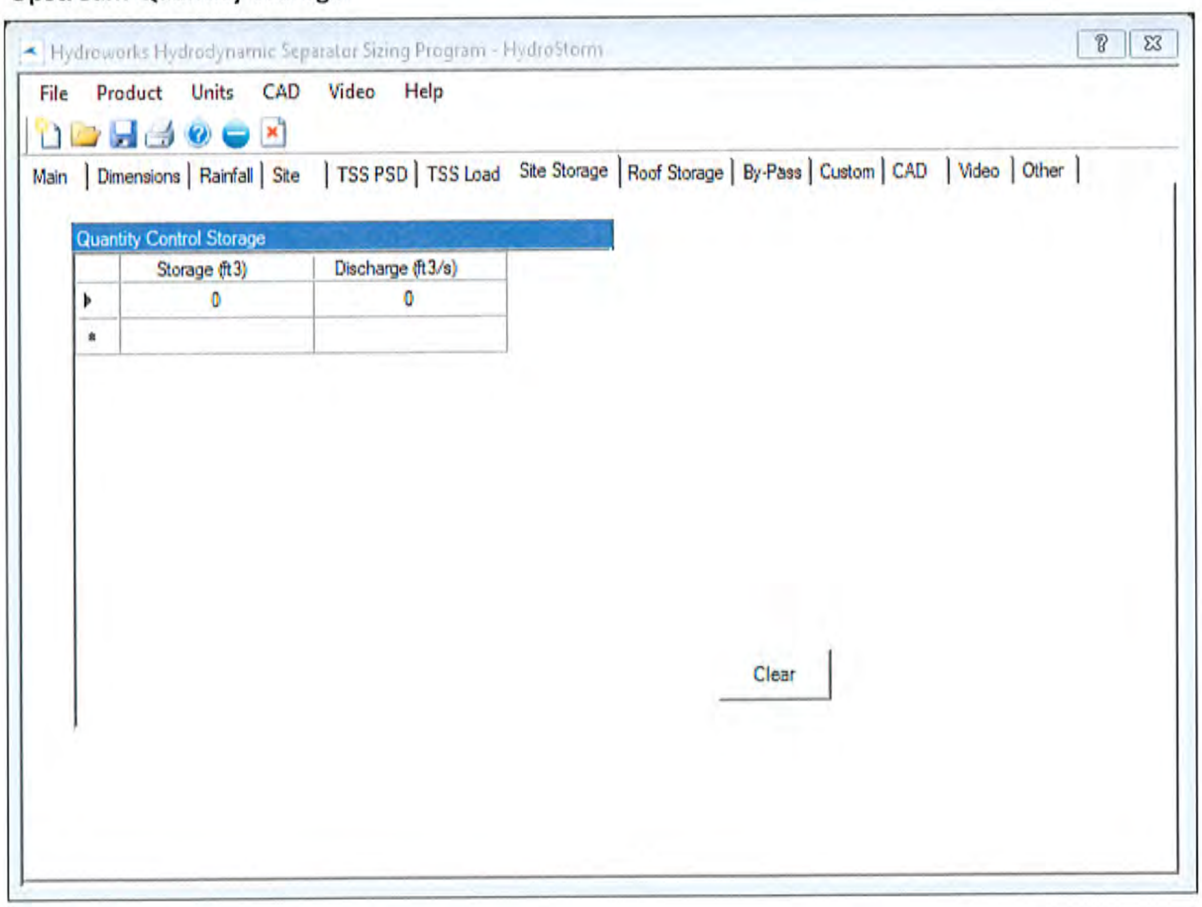
REVISION DATE:

Hydroworks

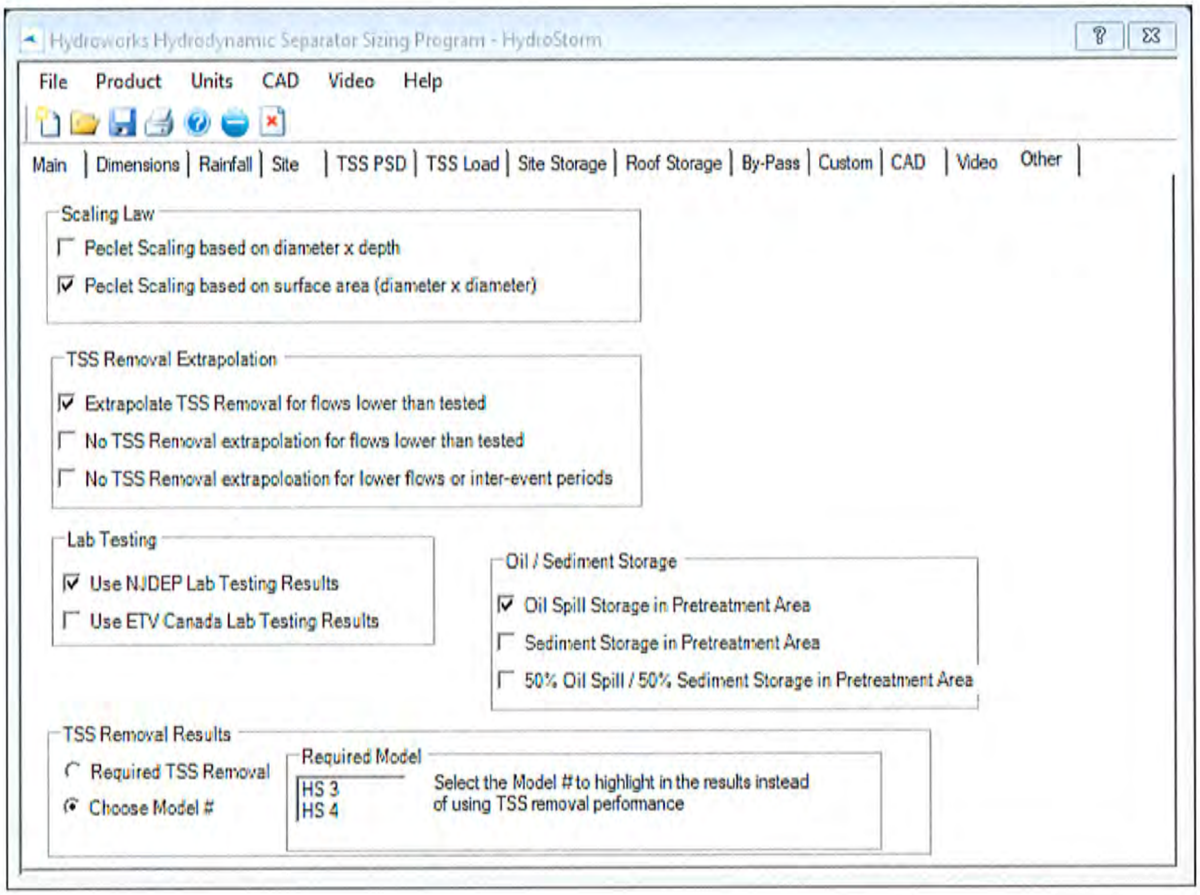
TSS Buildup And Washoff



Upstream Quantity Storage



Other Parameters



Flagged Issues

None

Hydroworks Sizing Program - Version 5.9

1-800-290-7900
www.hydroworks.com

APPENDIX 4

MADEQ WQF Calculations

HD 1

State	MA
Rain (in)	1
SCS Type	III
Area (ac)	4.79
Imp (%)	68
P (in)	1
Rv	0.66
Q (in)	1.00
CN	98
Ia	0.041
Ia/P	0.034
tc	0.20
qu	669
WQF (cfs)	3.40

For the State of MA the runoff (Q) is calculated from the impervious area as either 1" or 0.5" over the impervious area. We have assumed 1" of runoff for this project.

Therefore Q = 1" and IA = 3.257 ac = 0.005089 mi^2

For 1" of runoff MADEP requires that Ia/P be 0.034.

Assuming a time of concentration of 12 min, qu becomes 669

The water quality flow is therefore:

WQF = qu A Q

WQF = 669 x 0.005089 x 1

WQF = 3.4 cfs

HD 2

State	MA
Rain (in)	1
SCS Type	III
Area (ac)	1.13
Imp (%)	27
P (in)	1
Rv	0.41
Q (in)	1.00
CN	98
Ia	0.041
Ia/P	0.034
tc	0.10
qu	774
WQF (cfs)	0.37

For the State of MA the runoff (Q) is calculated from the impervious area as either 1" or 0.5" over the impervious area. We have assumed 1" of runoff for this project.

Therefore Q = 1" and IA = 0.305 ac = 0.000477 mi^2

For 1" of runoff MADEP requires that Ia/P be 0.034.

Assuming a time of concentration of 6 min, qu becomes 774

The water quality flow is therefore:

WQF = qu A Q

WQF = 774 x 0.000477 x 1

WQF = 0. 4 cfs

HD 3

State	MA
Rain (in)	1
SCS Type	III
Area (ac)	0.67
Imp (%)	65
P (in)	1
Rv	0.64
Q (in)	1.00
CN	98
Ia	0.041
Ia/P	0.034
tc	0.10
qu	774
WQF (cfs)	0.53

For the State of MA the runoff (Q) is calculated from the impervious area as either 1" or 0.5" over the impervious area. We have assumed 1" of runoff for this project.

Therefore Q = 1" and IA = 0.436 ac = 0.000680 mi^2

For 1" of runoff MADEP requires that Ia/P be 0.034.

Assuming a time of concentration of 6 min, qu becomes 774

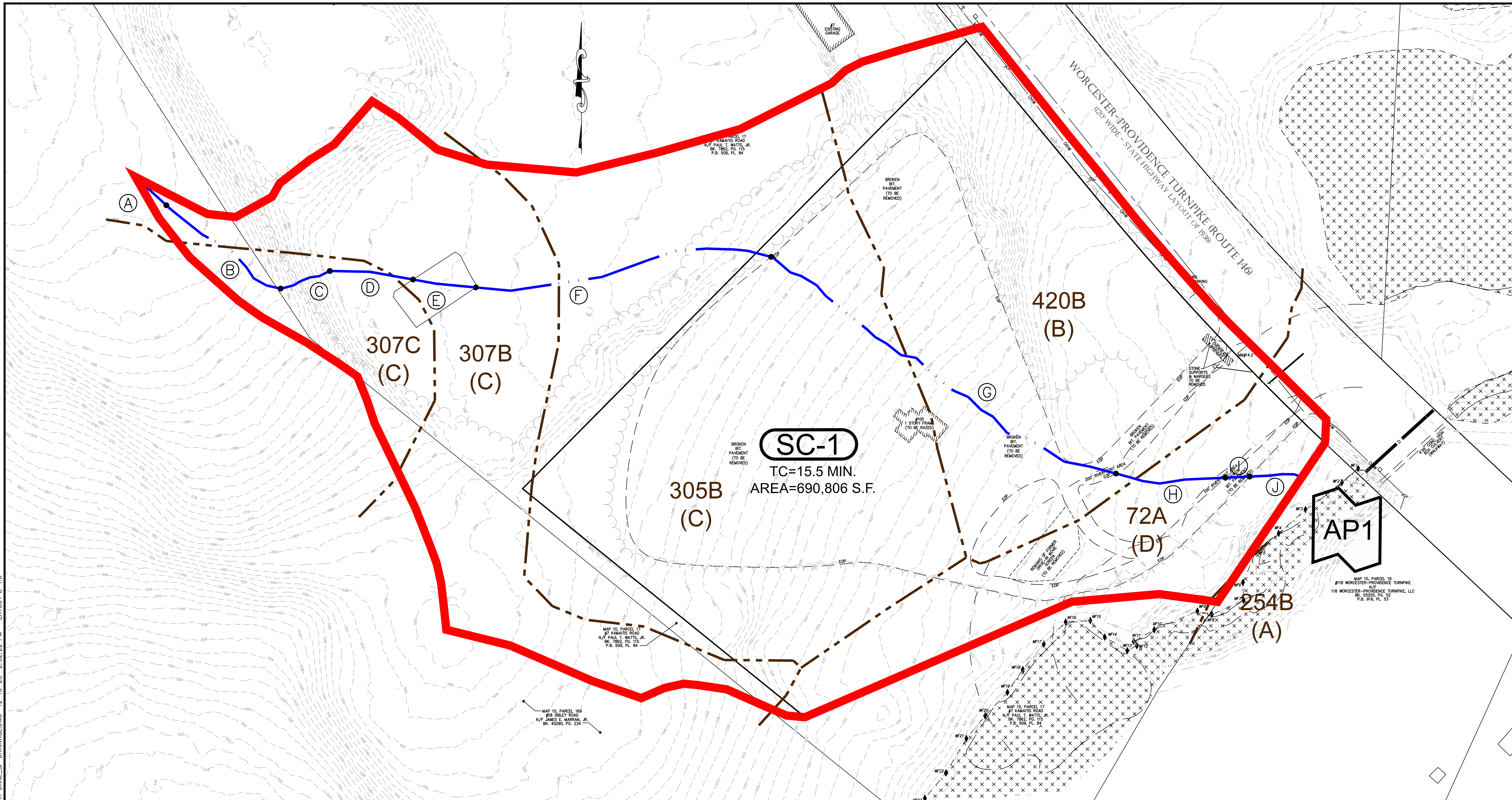
The water quality flow is therefore:

WQF = qu A Q

WQF = 774 x 0.000680 x 1

WQF = 0. 5 cfs

PART IV – MAPS



LEGEND

(red line)	SUBCATCHMENT LIMIT
SC-1	SUBCATCHMENT LABEL
(blue dash-dot line)	TIME OF CONCENTRATION
AP1	DRAINAGE ANALYSIS POINT
(brown line)	MAPPED SOIL BOUNDARY
254B (A)	SOIL MAP UNIT & HYDROLOGIC SOIL GROUP LISTING

TURNING POINT ENGINEERING
CIVIL SITE DESIGN
P.O. Box 757 • Sutton, MA 01590
P:(508) 381-1515 F:(508) 647-0189
www.tpecivildesign.com

PROJECT NAME
NORTHEAST GREAT DANE
#100 WORCESTER-PROVIDENCE TURNPIKE
SUTTON, MASSACHUSETTS

SUTTON MOTOR-IN TRUST
ONE MERCANTILE STREET, SUITE 540
WORCESTER, MA 01608

PREPARED FOR
Eastland
Eastland Partners, Inc.
997 Millbury Street
Worcester, MA 01607

REVISIONS

REV.	DATE	DESCRIPTION

PROJECT NO.	TPE-1126
DESIGNED BY	TB, WCN
CHECKED BY	SO
DATE	12/7/23
CAD FILE	H:\1126...GREAT DANE_SP Drainage
PLAN NO.	XXX

GRAPHIC SCALE
60 0 30 60 120
(IN FEET)
1 inch = 60 feet

SHEET TITLE
PRE-DEVELOPMENT DRAINAGE MAP

SHEET NO.
D-1.0

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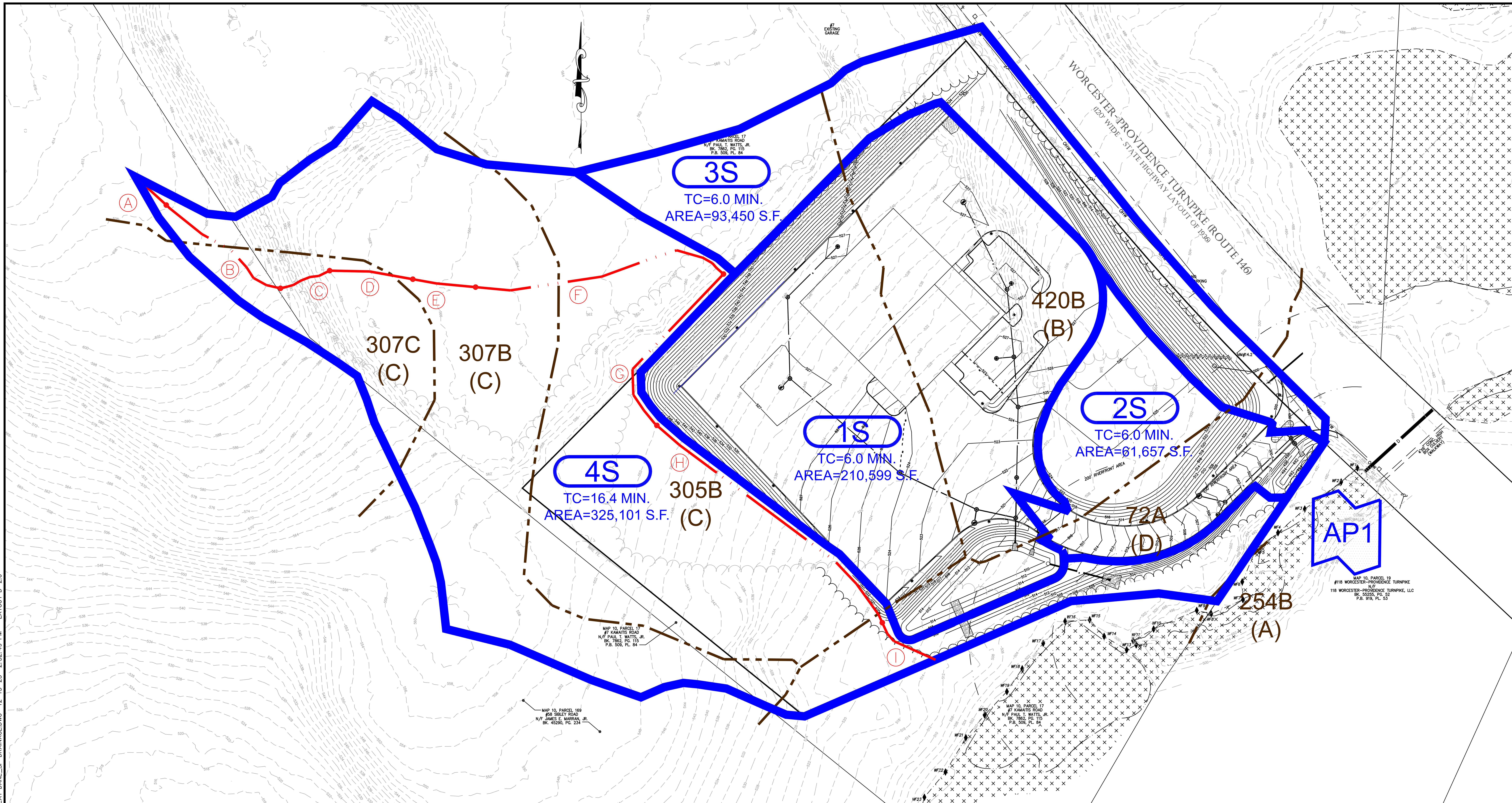

LEGEND

SUBCATCHMENT LIMIT

1S — SUBCATCHMENT LABEL

TIME OF CONCENTRATION

AP1 — DRAINAGE ANALYSIS POINT

MAPPED SOIL BOUNDARY

254B (A) — SOIL MAP UNIT & HYDROLOGIC SOIL GROUP LISTING

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TURNING POINT ENGINEERING
CIVIL SITE DESIGN
P.O. Box 969 • Milford, MA 01757
P:(508) 381-1515 F:(508) 647-0189
www.tpecivildesign.com

PROJECT NAME
NORTHEAST GREAT DANE
#100 WORCESTER-PROVIDENCE TURNPIKE
SUTTON, MASSACHUSETTS

SUTTON MOTOR-IN TRUST
ONE MERCANTILE STREET, SUITE 540
WORCESTER, MA 01608

PREPARED FOR
Eastland Partners, Inc.
997 Millbury Street
Worcester, MA 01607

REVISIONS

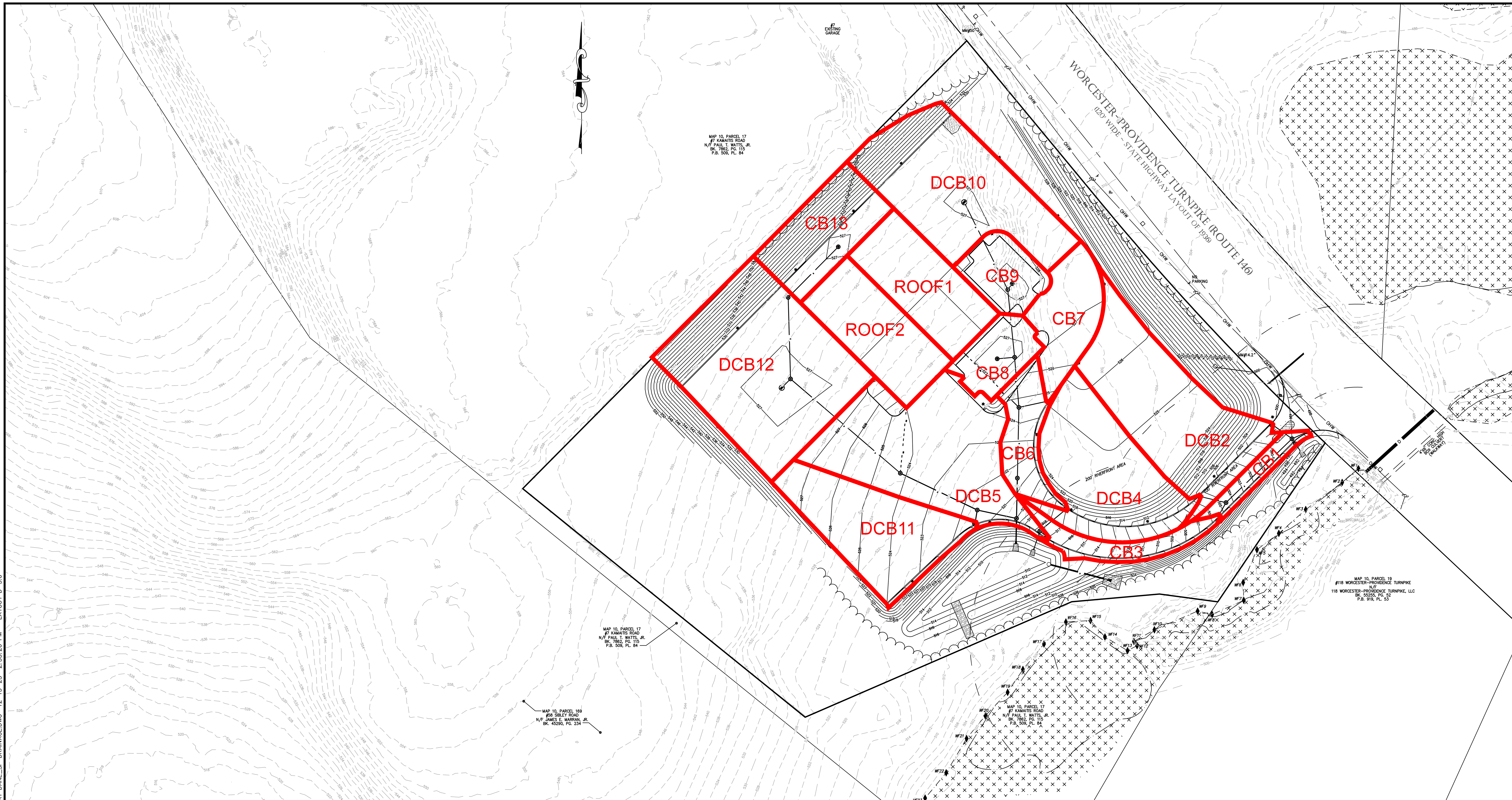
REV.	DATE	DESCRIPTION

PROJECT NO.	TPE-1126
DESIGNED BY	TB, WCN
CHECKED BY	SO
DATE	12/7/23
CAD FILE	H:\1126...GREAT DANE_SP Drainage
PLAN NO.	XXX

GRAPHIC SCALE
(IN FEET)
1 inch = 50 feet

SHEET TITLE
POST DEVELOPMENT DRAINAGE MAP

SHEET NO.
D-2.0



TURNING POINT ENGINEERING
CIVIL SITE DESIGN
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P:(508) 381-1515 F:(508) 647-0189
www.tpecivildesign.com

PROJECT NAME

NORTHEAST GREAT DANE

#100 WORCESTER-PROVIDENCE TURNPIKE
SUTTON, MASSACHUSETTS

SUTTON MOTOR-IN TRUST
ONE MERCANTILE STREET, SUITE 540
WORCESTER, MA 01608

PREPARED FOR

Eastland

REVISIONS

REV.	DATE	DESCRIPTION

PROJECT NO.	TPE-1126
DESIGNED BY	TB, WCN
CHECKED BY	SO
DATE	12/7/23
CAD FILE	H:\1126...GREAT DANE_SP Drainage
PLAN NO.	XXX

GRAPHIC SCALE

40 0 20 40 80

(IN FEET)
1 inch = 40 feet

SHEET TITLE

CATCH BASIN AREAS MAP

SHEET NO.

D-3.0

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