Stormwater Analysis

Monarch Drive
Littleton, Massachusetts

Permit Set – April 2022

Planning
Landscape
Architecture
Civil
Engineering
Surveying

PREPARED FOR:

VMD Industries V LLC

PLACES Associates, Inc.
256 Great Road, Suite 4, Littleton, MA 01460
(978) 486-0334 www.placesassociates.com

COMMONWEALTH OF MASSACHUSETTS
Susan E. Carter
CIVIL ENGINEER
NO. 41270
REGISTERED PROFESSIONAL ENGINEER

Date: April 2022
Rev. June 24, 2022
Rev. July 14, 2022

Table of Contents:

Executive Summary

***In response to peer review comments and further design refinement of the proposed building, updates to the drainage design and report include:**

- **The rainfall events utilized in the HydroCAD computer analysis were updated to an NRCS NOAA storm. This provides a localized rainfall event with more recent stormwater events taken into consideration in the statistical analysis that determines the rainfall depths.**
- **Minor volume changes in ponds 300 and 165 to reflect the existing berm of elevation elevation of 228.65 (previously modeled as 228.50).**
- **Total Suspended Solids calculations for the CDS stormwater treatment units.**
- **Expanded Operation and Maintenance Plan and BMP Map.**

The proposed site development will be the construction of a 98,000 s.f. industrial building. As the exact usage of the building is not yet determined, the perimeter of the parking/driveway area has been designed so that the southerly end of the building can accommodate either parking or loading bays. Loading bays will be provided at the northerly end of the building under all scenarios.

As this site is in an environmentally sensitive area as it is in the Aquifer Protection district as well as in a priority habitat area. As a result, the water quality volume is based on a 1" first flush and Low Impact Development techniques are preferable.

There are three general design methodologies being used to treat, infiltrate and attenuate runoff from the site. Tree Box Filters will be utilized along the perimeter of the parking areas, two different styles are utilized to provide a curb inlet in the front of the building and a drop inlet along the perimeter. These Tree Box Filters will be interconnected with a subsurface recharge trench that ultimately discharges into recharge basins or infiltration bed.

At the loading dock areas, the pavement pitches to a localized low area where a trench drain will capture the runoff and direct it to a hydrodynamic separator. In the event of a hazardous materials spill, a gate valve is provided prior to the hydrodynamic separator so that the contamination can be contained within the paved area immediately adjacent to the loading docks. Treated runoff from the loading docks as well as overflow from the Tree Filter Boxes is discharged into infiltration basins.

The point of analysis for the site is the northwesterly end of the drainage ditch (now BVW) as it enters the existing pond on Lot 1. A summary table of the flows is below:

HydroCAD Analysis Results				
	Storm Event Discharge Rates (cfs)			
Design Storm Event	**2-Year**	**10-Year**	**25-Year**	**100-Year**
Existing Conditions	**0.04**	**0.40**	**0.99**	**2.60**
Proposed Conditions	**0.04**	**0.32**	**0.94**	**2.48**

As Littleton is a MS4 community with a Stormwater By-law, calculations for Phosphorus removal have been included in these calculations. The total Phosphorus reduction from the developed portions of the site is 89.3 % (60% required)

This design is in full compliance with the MADEP stormwater management standards and incorporates best management practices (BMP's) consistent with low impact development (LID) and incorporates many of the concepts emphasized in LID design.

BMP's utilized:

- Tree Filter Box
- Hydrodynamic Separator
- Infiltration Basin
- Infiltration Trench

Introduction

Excerpt from MADEP Stormwater Management Standards Chapter 1:

> *In 1996, the Massachusetts Department of Environmental Protection (the "Department" or "MassDEP") issued the Stormwater Policy that established Stormwater Management Standards aimed at encouraging recharge and preventing stormwater discharges from causing or contributing to the pollution of the surface waters and groundwaters of the Commonwealth. In 1997, MassDEP published the Massachusetts Stormwater Handbook as guidance on the Stormwater Policy. MassDEP has revised the Stormwater Management Standards and Massachusetts Stormwater Handbook to promote increased stormwater recharge, the treatment of more runoff from polluting land uses, low impact development (LID) techniques, pollution prevention, the removal of illicit discharges to stormwater management systems, and improved operation and maintenance of stormwater best management practices (BMPs). MassDEP applies the Stormwater Management Standards pursuant to its authority under the Wetlands Protection Act, M.G.L. c. 131, § 40, and the Massachusetts Clean Waters Act, M.G.L.c. 21, §§ 26-53. The revised Stormwater Management Standards have been incorporated in the Wetlands Protection Act Regulations, 310 CMR 10.05(6)(k) and the Water Quality Certification Regulations, 314 CMR 9.06(6)(a).*
>
> *Stormwater runoff results from rainfall and snow melt and represents the single largest source responsible for water quality impairments in the Commonwealth's rivers, lakes, ponds, and marine waters. New and existing development typically adds impervious surfaces and, if not properly managed, may alter natural drainage features, increase peak discharge rates and volumes, reduce recharge to wetlands and streams, and increase the discharge of pollutants to wetlands and water bodies.*
>
> *The Stormwater Management Standards address water quality (pollutants) and water quantity (flooding, low base flow and recharge) by establishing standards that require the implementation of a wide variety of stormwater management strategies. These strategies include environmentally sensitive site design and LID techniques to minimize impervious surface and land disturbance, source control and pollution prevention, structural BMPs, construction period erosion and sedimentation control, and the long-term operation and maintenance of stormwater management systems.*

Narrative – Existing Conditions

The existing site is located at the end of Monarch Drive in Littleton, MA. The proposed site is comprised of Lots 2A and 2B containing 20.08 acres is currently vacant land. The site was formerly mined for gravel and the remaining land has been left with little or no topsoil resulting in sparse vegetation. The soils are A manmade ditch, now qualifying as wetlands, encircles the buildable portion of the site directly adjacent to the shared access driveway, opposite of the existing office building at 1 Monarch Drive. This drainage system flows from the southwest, around the buildable area, through a 24" culvert to the east and loops back to a manmade pond on Lot 1 to the northwest of the site. The end of this drainage ditch, prior to the discharge into the pond is the Point of Analysis for this site.

The surface cover on the front portion of the site is a combination of brush/weeds interspersed with some trees as well as barren soil. This area is being categorized as brush/grass/weeds in poor condition due to the sparse vegetation and exposed soils. Generally, the more established vegetation is located within the 50' buffer to the wetlands and has been classified as wood in poor condition reflective of the thin layer of topsoil and leaf litter. There is some planted and maintained lawn areas, directly adjacent to the access driveway which is considered grass in good condition.

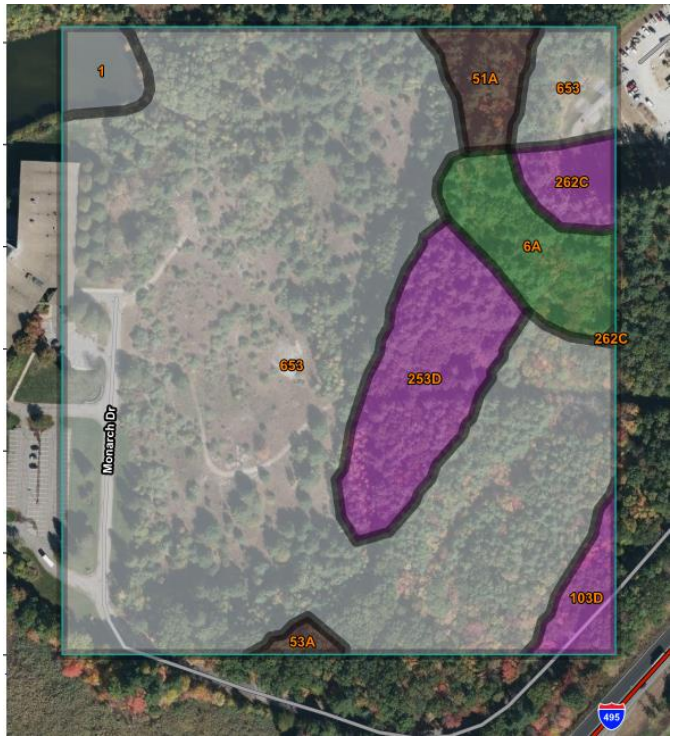
Access to the easterly side of the site is via a gravel road over the culvert. This area is wooded with tall pines and soil testing indicated 3-4" of topsoil, evidence of previous gravel mining operations. There is no shrub or herbaceous layer beneath the trees with thin forest litter, so these woods are considered fair condition.

In general, the site appears to have been graded for a pad development with a large portion of the buildable area at elevations 230 to 234. Elevations of the wetlands are approximately 224. Soil testing performed both for the current project and previous project are consistent with the groundwater table being at elevation 224 or lower.

Soils on this site are Hydrologic Group A containing udorthents and Hinckley loamy sand as indicated on the soils map below:

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1	Water		0.6	2.0%
6A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	A/D	1.6	5.3%
51A	Swansea muck, 0 to 1 percent slopes	B/D	0.8	2.7%
53A	Freetown muck, ponded, 0 to 1 percent slopes	B/D	0.2	0.6%
103D	Charlton-Hollis-Rock outcrop complex, 15 to 25 percent slopes	A	0.6	2.2%
253D	Hinckley loamy sand, 15 to 25 percent slopes	A	2.6	8.8%
262C	Quonset sandy loam, 8 to 15 percent slopes	A	0.7	2.2%
653	Udorthents, sandy		22.8	76.3%
Totals for Area of Interest			**29.9**	**100.0%**



This site is contained in a mapped habitat area. Under a previous development proposal for a hotel, a large portion of the site was placed in a Conservation Restriction and areas designated for specific uses such as drainage or septic areas. Utilities were installed to serve the building on Lot 1.

Narrative – Proposed Conditions

The proposed site development will be the construction of a 98,000 s.f. industrial building. As the exact usage of the building is not yet determined, the perimeter of the parking/driveway area has been designed so that the southerly end of the building can accommodate either parking or loading bays. Loading bays will be provided at the northerly end of the building under all scenarios.

As this site is in an environmentally sensitive area as it is in the Aquifer Protection district as well as in a priority habitat area. As a result, the water quality volume is based on a 1" first flush and Low Impact Development techniques are preferable.

There are three general design methodologies being used to treat, infiltrate and attenuate runoff from the site. The first is with the use of Tree Filter Boxes. These will be used to capture and pre-treat the runoff from the parking areas and site driveway. There are two basic types of Tree Filter Boxes (TFB) proposed. The first is the traditional TFB where runoff enters the TFB from a curb inlet and the area around the base of the tree is covered in a tree gate. These TFB will be used adjacent to the parking areas at the front (west side) of the building. These areas are more removed from the perimeter of the site and are less likely to intercept young animals.

At the outer perimeter of the parking and loading dock areas, the second type of TFB will be utilized. These TFB will be comprised of an open bottom structure, set just below the elevation of the edge of pavement, dropping 6" to a bark mulch surface surrounding the tree. Parking lot runoff will enter the TFB via a break in the berm. This design will allow the surface surrounding the tree to be visible and if any animals are within the TFB, they can easily be viewed and freed. Both types of TFB will be interconnected with a 12" perforated pipe, set level, to allow recharge.

The catchbasin in the middle of the parking area at the front (west side) of the building must be pre-treated prior to discharge into subsurface chambers. A hydrodynamic separator, with a catchbasin grate will provide the pretreatment and direct the runoff into the chambers for recharge and attenuation.

At each loading dock area, at the north and south ends of the building, the intent is to provide emergency storage should there be any type of spill at the loading docks. The parking slopes from the loading dock to a trench drain at a localized low area. Runoff from the trench drain is routed into a catchbasin then via pipe to a hydrodynamic separator. Between the manhole and separator there will be a shut off valve. The area around the trench drain will contain a spill until it can be cleaned. From the hydrodynamic separator, the pretreated runoff will be directed into the infiltration basins on the easterly side of the building.

As Littleton is a MS4 community with a Stormwater By-law, calculations for Phosphorus removal have been included in these calculations.

This design is in full compliance with the MADEP stormwater management standards and incorporates best management practices (BMP's) consistent with low impact development (LID) and incorporates many of the concepts emphasized in LID design.

BMPs utilized:

- Tree Filter Box
- Hydrodynamic Separator
- Infiltration Basin
- Infiltration Trench

LID/Environmentally Sensitive Design Techniques utilized (Volume 1- Chapter 1):

- *Maintain as much of the pre-development vegetation as possible*
- *Maintain natural buffers and drainage ways*
- *Utilize country style drainage*

Narrative – Hydrologic Analysis

The point of analysis for the hydrologic analysis is the outlet from the existing drainage ditch, shown as Reach 3 in both the Pre and Post Development calculations.

In order to achieve both the attenuation of flow rates and a reduction in the total Phosphorus from the site recharge is required. This design has maximized the recharge to the extent practicable in order to achieve no increase in the rate of runoff for the 2 year storm event. The infiltration and stormwater basin system has been designed for overflow at the surface in order to meet the 50' no disturbance buffer zone to the wetlands. As a result, the surface stormwater basins do not overflow in the 2, 10 or 25 year storm events.

The soils on the site are a well sorted sand, with a percolation rate in excess of 2 minutes per inch. It is anticipated that runoff infiltrating into the groundwater will migrate to the same wetlands, helping to sustain the hydrology of those wetlands, despite the decrease in the rate of runoff.

The wooded area, to the east of the culvert crossing will be cleared for the septic system installation. The existing woods are considered to be Woods, fair condition due to the 3-4" of topsoil, absence of understory vegetation, both herbaceous and shrubs, and a very minimal surface litter. The Curve Number for these conditions, with A soils is 43. Under post development, the areas for the leaching field will be stabilized with 6" of loam and a conservation grass seed mix. As this area is not directly adjacent to the building, it is anticipated that it will be mowed several times a year, not weekly as the grass areas adjacent to the building. Once this area is fully vegetated, will likely have a combination of grasses, weeds and some brush given the presence of weed seed in the adjacent natural areas, in fair condition due to the excessively drained soils. Brush/weed/grass mix in fair condition has a curve number of 35. As a result, no changes are anticipated in the runoff from this portion of the property.

Documenting Compliance

Standard 1 - No new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

No untreated outfalls are proposed.

Standard 2 - Stormwater management systems shall be designed so that the post-development peak discharge rates do not exceed pre-development peak discharge rates…To prevent storm damage and downstream and off-site flooding, Standard 2 requires that the post-development peak discharge rate is equal to or less than the pre-development rate from the 2-year and the 10-year 24-hour storms…Proponents must also evaluate the impact of peak discharges from the 100-year 24-hour storm. If this evaluation shows that increased off-site flooding will result from peak discharges from the 100-year 24-hour storms, BMPs must also be provided to attenuate these discharges.

The post development runoff calculations demonstrate no increase in the rate of runoff for any of the storms.

Standard 3 - Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.

Tributary Impervious area = 203,545 sq.ft. (buildings and pavement)
Class A soils = 0.6 inches x impervious area
Required recharge (Rv)= 203,545 sq.ft. x 0.6 inches x 1ft/12in = **10,177 cubic feet required**
Capture Area Adjustment:

Impervious surfaces tributary to Basins and Chambers = 132,540 + 27160+22,330=182,030
Ratio of total impervious to impervious to recharge=203,545/182,030=1.12
Adjusted minimum required recharge= 10,177x 1.12= **11,398 cubic feet required**

Static Recharge Provided (see HydroCAD output for details)

Infiltration Basin 1 (below overflow elevation 229.80**)** =	**29,380 c.f.**
Infiltration Basin 2 & 3 (below overflow elevation 228.65) =	**4,986 c.f.**
Infiltration Chambers (below outlet elevation of 228.0) =	**2,212 c.f.**
Total provided=	**36,578 c.f. < 11,398**

Drawdown times:

To simplify, only consider infiltration in basins, excluding recharge occurring between tree filter boxes

Infiltration Basin 1

Rv= 132,540 x 0.6 x 1 ft/12in= 6627 c.f.
Time= 6627 c.f./ (8.27 in/hr)(1ft/12in)(4545 s.f.)= 2.1 hours

Infiltration Basins 2 and 3

Rv=27160x 0.6x 1/12=1358 c.f.
Time= 1358 c.f./(8.27 in/hr)x 0.6 x1/12 x 1195)=2.75 hours

Infiltration Chambers

Rv=22,330x 0.6x 1/12=1117 c.f.
Time= 1117 c.f./(8.27 in/hr)x 0.6 x1/12 x 1544 s.f.)=1.74 hours

Groundwater Mounding:

Use USGS Groundwater Mounding Spreadsheet with the following parameters

Rv= Recharge Volume
Recharge Rate = Rv applied over bottom for 72 hours = Rv/(bot area s.f.)(3 days)
Sy for sand= 0.26
K Horizontal Hydraulic Conductivity for coarse sand = 55
X= ½ length basin
Y=1/2 width basin
T= duration of flow = 3 days
Hi= initial thickness of saturated zone (assume 20' min. since area is an Aquifer District)

Infiltration Basin 1

R= 6627 c.f./(4545 s.f.) x (3 days)= 0.49

Resulting Groundwater mound using Rv is 0.733'

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

Conversion Table

Input Values			inch/hour	feet/day	
0.4900	R	Recharge (infiltration) rate (feet/day)	0.67	1.33	
0.260	Sy	Specific yield, Sy (dimensionless, between 0 and 1)			
55.00	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00	In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).
51.000	x	1/2 length of basin (x direction, in feet)			
22.000	y	1/2 width of basin (y direction, in feet)	hours	days	
3.000	t	duration of infiltration period (days)	36	1.50	
15.000	hi(0)	initial thickness of saturated zone (feet)			
15.733	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)			
0.733	Δh(max)	maximum groundwater mounding (beneath center of basin at end of infiltration period)			

Infiltration Basins 2 and 3

R= 1358 c.f./3 days (1195 s.f)= 0.37

Resulting Groundwater mound using Rv is 0.187

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

Conversion Table

Input Values			inch/hour	feet/day	
0.3700	R	Recharge (infiltration) rate (feet/day)	0.67	1.33	
0.260	Sy	Specific yield, Sy (dimensionless, between 0 and 1)			
55.00	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00	In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).
41.000	x	1/2 length of basin (x direction, in feet)			
7.500	y	1/2 width of basin (y direction, in feet)	hours	days	
3.000	t	duration of infiltration period (days)	36	1.50	
15.000	hi(0)	initial thickness of saturated zone (feet)			
15.187	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)			
0.187	Δh(max)	maximum groundwater mounding (beneath center of basin at end of infiltration period)			

Infiltration Chambers

R= 1117 c.f./3 days (1544 s.f)= 0.03

Resulting Groundwater mound using Rv is 0.02’

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

Conversion Table

Input Values			inch/hour	feet/day	
0.0300	R	Recharge (infiltration) rate (feet/day)	0.67	1.33	
0.260	Sy	Specific yield, Sy (dimensionless, between 0 and 1)			
55.00	K	Horizontal hydraulic conductivity, Kh (feet/day)*	2.00	4.00	In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).
33.000	x	1/2 length of basin (x direction, in feet)			
12.000	y	1/2 width of basin (y direction, in feet)	hours	days	
3.000	t	duration of infiltration period (days)	36	1.50	
15.000	hi(0)	initial thickness of saturated zone (feet)			
15.020	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)			
0.020	Δh(max)	maximum groundwater mounding (beneath center of basin at end of infiltration period)			

Standard 4 - Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS).

For purposes of Standards 3 and 4, impervious surfaces include roads, rooftops, parking lots, and sidewalks, when they are paved with concrete, asphalt, or brick pavers. (Volume 3, Chapter 1, Page 15)

Parking lot areas		Removal Rate	Remains	
Pretreatment	Tree Filter Box	85%	15%	
Treatment	Infiltration	80%	3%	
Final Rate			**97%**	removal

* Tree Filter Box provided at a rate of 1/0.1 Ac. Impervious or less in compliance with UNH Stormwater Center Guidelines

Loading Dock Areas		Removal Rate	Remains	
Pretreatment	Hydrodynamic separator	96%	4%	
Treatment	Infiltration	80%	1%	
Final Rate			**99%**	removal

CTB front of building		Removal Rate	Remains	
Pretreatment	Hydrodynamic separator	96%	4%	
Treatment	Infiltration	80%	1%	
Final Rate			**99%**	removal

Standard 5 - For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If through source control and/or pollution prevention all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use the specific structural stormwater BMPs determined by the Department to be suitable for such uses as provided in the Massachusetts Stormwater Handbook. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.

The project does not qualify as a LUHPPL.

Standard 6 - Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook. A discharge is near a critical area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "storm water discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an

Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.

This site is within a mapped Priority Habitat area. All discharge points are outside of the existing Conservation Restriction Area. The drainage design has incorporated multiple infiltration basins where the outlet utilizes natural low points or overflow weirs located outside the limits of the CR. The exception is the discharges near the cul-de-sac of Monarch Drive where existing grades in Monarch Drive are low, eliminating the ability to daylight the drainage system outside of the 50' vegetative buffer to the wetlands.

Standard 7 - A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.

The project is not proposed as redevelopment.

Standard 8 - A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.

See site plans included with this application.

Standard 9 - A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.

See the Operation and Maintenance Plan included in this document.

Standard 10 - All illicit discharges to the stormwater management system are prohibited.

Illicit Discharge Compliance Statement

To the best of my knowledge no illicit discharges currently exist on the site and no future illicit discharge will be allowed, including wastewater discharges and discharges of stormwater contaminated by contact with process wastes, raw materials, toxic pollutants, hazardous substances, oil, or grease.

_____

Signature of Owner Date

To be completed and submitted prior to the start of construction.

PHOSPHORUS REMOVAL:

MS4 requirements for 60% Total Phosphorous Removal.

IA= Impervious Area
PA= Pervious Area

Calculations:

BMP Design Volume = storage volume in basin which is available for recharge
IA Rainfall depth= depth of rainfall that would generate the BMP volume in the Basin.
PA BMP Volume= volume generated by the pervious areas using the IA rainfall depth and Chart 3-3 using soil type and surface cover to generate the volume (Excel chart for each BMP)
P Load= Phosphorus load based on surface cover (Appendix F, Attachment 3, Pg. 10)
BMP Reduction (%) = BMP Performance curve using infiltration rate and depth of runoff from the IA

Basin 1 (Pond 165):

Basin 1 has
Design Vol=29,380 c.f.
Infiltration Rate=8.27
Tributary Impervious= 132,540; Pervious (landscaped)= 27,585 s.f.

IA Rainfall Depth= (29,380 c.f.)/132,540 s.f. imp= 0.22 feet=2.66 inches

Note: Table 3-15 provides runoff depths for pervious surfaces with initial rainfall depths up to 2". The 100% P removal occurs with rainfall depth of 1.5" which is less than the IA rainfall depth. Therefore, these calculations will determine the minimum volume needed to achieve 100% Phosphorus removal.

From BMP Performance Curve: Infiltration Basin (Infiltration Rate = 8.27 in/hr), 100% Pollutant level is achieved with a 1.5" Depth of Runoff from the IA.

IA Rainfall Depth = 1.5"
IA Volume= IA depth (in)x 1'/12"x IA = 1.5"x1'/12"x 132,540 s.f.= 16,568 c.f
PA use Rainfall Depth 1.5" and excel spreadsheet to calculated volume of pervious areas= 322

Basin Volume for 100% P Reduction (1.5" Rainfall Depth) = IA Volume + PA Volume = 16,890 c.f. < 29,380c.f., therefore 100% reduction is achieved.

Basin 2 and 3 (Ponds 300 and 301):

Basins 2 and 3 have:
Design Vol=4,986 c.f.
Infiltration Rate=8.27
Tributary Impervious= 27,160; Pervious (landscaped)= 33,305 s.f.

IA Rainfall Depth= (4,986 c.f.)/27,160 s.f. imp= 0.183 feet=2.20 inches

Note: Table 3-15 provides runoff depths for pervious surfaces with initial rainfall depths up to 2". The 100% P removal occurs with rainfall depth of 1.5" which is less than the IA rainfall depth. Therefore, these calculations will determine the minimum volume needed to achieve 100% Phosphorus removal.

From BMP Performance Curve: Infiltration Basin (Infiltration Rate = 8.27 in/hr), 100% Pollutant level is achieved with a 1.5" Depth of Runoff from the IA.

IA Rainfall Depth = 1.5"
IA Volume= IA depth (in)x 1'/12"x IA = 1.5"x1'/12"x 27,160 s.f.= 3,395 c.f
PA use Rainfall Depth 1.5" and excel spreadsheet to calculated volume of pervious areas= 389

Basin Volume for 100% P Reduction (1.5" Rainfall Depth) = IA Volume + PA Volume = 3,784 c.f. < 4,115 c.f., therefore 100% reduction is achieved.

Infiltration Trenches and Infiltration Chamber (Ponds 220 and 222):

Design Vol=3,777 c.f.
Infiltration Rate=8.27
Tributary Impervious= 22,330; Pervious (landscaped)= 3845 s.f.

IA Rainfall Depth= (3,777 c.f.)/22,330 s.f. imp= 0.169 feet =2.03 inches

Note: Table 3-9 provides runoff depths for pervious surfaces with initial rainfall depths up to 2". The 100% P removal occurs with rainfall depth of 1.5" which is less than the IA rainfall depth. Therefore, these calculations will determine the minimum volume needed to achieve 100% Phosphorus removal.

From BMP Performance Curve: Infiltration Basin (Infiltration Rate = 8.27 in/hr), 100% Pollutant level is achieved with a 1.5" Depth of Runoff from the IA.

IA Rainfall Depth = 1.5"
IA Volume= IA depth (in)x 1'/12"x IA = 1.5"x1'/12"x 22,330 s.f.= 2,791 c.f
PA use Rainfall Depth 1.5" and excel spreadsheet to calculated volume of pervious areas= 45

Basin Volume for 100% P Reduction (1.5" Rainfall Depth) = IA Volume + PA Volume = 2,836 c.f. < 3,777 c.f., therefore 100% reduction is achieved.

TOTAL REDUCTION OF PHOSPHORUS LOAD SITEWIDE = 89.38 % >60%

Supporting Data – Phosphorus Removal

Stage-Area-Storage for Pond 165: infiltration basin

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
226.00	4,515	0
226.05	4,592	228
226.10	4,668	459
226.15	4,745	694
226.20	4,821	934
226.25	4,898	1,177
226.30	4,974	1,423
226.35	5,050	1,674
226.40	5,127	1,928
226.45	5,203	2,187
226.50	5,280	2,449
226.55	5,357	2,715
226.60	5,433	2,984
226.65	5,510	3,258
226.70	5,586	3,535
226.75	5,663	3,817
226.80	5,739	4,102
226.85	5,815	4,390
226.90	5,892	4,683
226.95	5,968	4,980
227.00	6,045	5,280
227.05	6,135	5,585
227.10	6,226	5,894
227.15	6,316	6,207
227.20	6,407	6,525
227.25	6,497	6,848
227.30	6,587	7,175
227.35	6,678	7,506
227.40	6,768	7,843
227.45	6,859	8,183
227.50	6,949	8,529
227.55	7,039	8,878
227.60	7,130	9,232
227.65	7,220	9,591
227.70	7,311	9,954
227.75	7,401	10,322
227.80	7,491	10,695
227.85	7,582	11,071
227.90	7,672	11,453
227.95	7,763	11,839
228.00	7,853	12,229
228.05	7,950	12,624
228.10	8,047	13,024
228.15	8,144	13,429
228.20	8,240	13,838
228.25	8,337	14,253
228.30	8,434	14,672
228.35	8,531	15,096
228.40	8,628	15,525
228.45	8,725	15,959
228.50	8,822	16,398
228.55	8,918	16,841
228.60	9,015	17,289
228.65	9,112	17,743
228.70	9,209	18,201
228.75	9,306	18,664
228.80	9,403	19,131
228.85	9,499	19,604
228.90	9,596	20,081
228.95	9,693	20,563
229.00	9,790	21,051
229.05	9,868	21,542
229.10	9,945	22,037
229.15	10,023	22,536
229.20	10,101	23,040
229.25	10,179	23,547
229.30	10,257	24,057
229.35	10,334	24,572
229.40	10,412	25,091
229.45	10,490	25,613
229.50	10,568	26,140
229.55	10,645	26,670
229.60	10,723	27,204
229.65	10,801	27,742
229.70	10,878	28,284
229.75	10,956	28,830
229.80	11,034	29,380
229.85	11,112	29,934
229.90	11,190	30,491
229.95	11,267	31,053
230.00	**11,345**	**31,618**

Stage-Area-Storage for Pond 220: Infiltration Chambers

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
226.00	**1,556**	0
226.05	1,556	31
226.10	1,556	62
226.15	1,556	93
226.20	1,556	125
226.25	1,556	156
226.30	1,556	187
226.35	1,556	218
226.40	1,556	249
226.45	1,556	280
226.50	1,556	311
226.55	1,556	380
226.60	1,556	448
226.65	1,556	515
226.70	1,556	582
226.75	1,556	649
226.80	1,556	716
226.85	1,556	782
226.90	1,556	848
226.95	1,556	915
227.00	1,556	981
227.05	1,556	1,046
227.10	1,556	1,111
227.15	1,556	1,176
227.20	1,556	1,240
227.25	1,556	1,304
227.30	1,556	1,367
227.35	1,556	1,431
227.40	1,556	1,493
227.45	1,556	1,556
227.50	1,556	1,618
227.55	1,556	1,680
227.60	1,556	1,742
227.65	1,556	1,803
227.70	1,556	1,863
227.75	1,556	1,923
227.80	1,556	1,982
227.85	1,556	2,041
227.90	1,556	2,099
227.95	1,556	2,156
228.00	1,556	2,212
228.05	1,556	2,267
228.10	1,556	2,322
228.15	1,556	2,375
228.20	1,556	2,428
228.25	1,556	2,479
228.30	1,556	2,529
228.35	1,556	2,577
228.40	1,556	2,623
228.45	1,556	2,668
228.50	1,556	2,709
228.55	1,556	2,747
228.60	1,556	2,782
228.65	1,556	2,815
228.70	1,556	2,847
228.75	1,556	2,878
228.80	1,556	2,909
228.85	1,556	2,940
228.90	1,556	2,971
228.95	1,556	3,002
229.00	1,556	3,034
229.05	1,556	3,065
229.10	1,556	3,096
229.15	1,556	3,127
229.20	1,556	**3,158**

Stage-Area-Storage for Pond 222: Tree Filter Infiltration

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
227.00	**690**	0
227.02	690	5
227.04	690	9
227.06	690	14
227.08	690	19
227.10	690	24
227.12	690	29
227.14	690	35
227.16	690	40
227.18	690	46
227.20	690	52
227.22	690	58
227.24	690	65
227.26	690	71
227.28	690	78
227.30	690	85
227.32	690	93
227.34	690	100
227.36	690	108
227.38	690	116
227.40	690	124
227.42	690	133
227.44	690	141
227.46	690	150
227.48	690	158
227.50	690	167
227.52	690	176
227.54	690	185
227.56	690	194
227.58	690	203
227.60	690	212
227.62	690	221
227.64	690	230
227.66	690	239
227.68	690	248
227.70	690	257
227.72	690	266
227.74	690	276
227.76	690	285
227.78	690	294
227.80	690	303
227.82	690	311
227.84	690	320
227.86	690	329
227.88	690	338
227.90	690	346
227.92	690	355
227.94	690	363
227.96	690	372
227.98	690	380
228.00	690	388
228.02	690	395
228.04	690	403
228.06	690	410
228.08	690	417
228.10	690	423
228.12	690	430
228.14	690	436
228.16	690	442
228.18	690	448
228.20	690	454
228.22	690	459
228.24	690	464
228.26	690	470
228.28	690	474
228.30	690	479
228.32	690	484
228.34	690	489
228.36	690	493
228.38	690	498
228.40	690	502
228.42	690	507
228.44	690	512
228.46	690	516
228.48	690	521
228.50	690	525
228.52	690	530
228.54	690	535
228.56	690	539
228.58	690	544
228.60	690	548
228.62	690	553
228.64	690	558
228.66	690	562
228.68	690	567
228.70	690	571
228.72	690	576
228.74	690	581
228.76	690	585
228.78	690	590
228.80	690	594
228.82	690	599
228.84	690	604
228.86	690	608
228.88	690	613
228.90	690	617
228.92	690	622
228.94	690	626
228.96	690	631
228.98	690	636
229.00	690	**640**

Stage-Area-Storage for Pond 300: Infiltration 1

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
227.00	900	0
227.02	920	18
227.04	940	37
227.06	961	56
227.08	981	75
227.10	1,001	95
227.12	1,021	115
227.14	1,042	136
227.16	1,062	157
227.18	1,082	178
227.20	1,102	200
227.22	1,122	222
227.24	1,143	245
227.26	1,163	268
227.28	1,183	292
227.30	1,203	315
227.32	1,224	340
227.34	1,244	364
227.36	1,264	390
227.38	1,284	415
227.40	1,304	441
227.42	1,325	467
227.44	1,345	494
227.46	1,365	521
227.48	1,385	548
227.50	1,406	576
227.52	1,426	605
227.54	1,446	633
227.56	1,466	663
227.58	1,486	692
227.60	1,507	722
227.62	1,527	752
227.64	1,547	783
227.66	1,567	814
227.68	1,587	846
227.70	1,608	878
227.72	1,628	910
227.74	1,648	943
227.76	1,668	976
227.78	1,689	1,010
227.80	1,709	1,044
227.82	1,729	1,078
227.84	1,749	1,113
227.86	1,769	1,148
227.88	1,790	1,183
227.90	1,810	1,219
227.92	1,830	1,256
227.94	1,850	1,293
227.96	1,871	1,330
227.98	1,891	1,367
228.00	1,911	1,406
228.02	2,012	1,445
228.04	2,113	1,486
228.06	2,214	1,529
228.08	2,316	1,575
228.10	2,417	1,622
228.12	2,518	1,671
228.14	2,619	1,723
228.16	2,720	1,776
228.18	2,821	1,831
228.20	2,923	1,889
228.22	3,024	1,948
228.24	3,125	2,010
228.26	3,226	2,073
228.28	3,327	2,139
228.30	3,428	2,206
228.32	3,530	2,276
228.34	3,631	2,348
228.36	3,732	2,421
228.38	3,833	2,497
228.40	3,934	2,575
228.42	4,035	2,654
228.44	4,137	2,736
228.46	4,238	2,820
228.48	4,339	2,905
228.50	4,440	2,993
228.52	4,679	3,084
228.54	4,918	3,180
228.56	5,157	3,281
228.58	5,396	3,387
228.60	5,635	3,497
228.62	5,874	3,612
228.64	6,113	3,732
228.66	6,352	3,857
228.68	6,591	3,986
228.70	6,830	4,120
228.72	7,069	4,259
228.74	7,308	4,403
228.76	7,548	4,552
228.78	7,787	4,705
228.80	8,026	4,863
228.82	8,265	5,026
228.84	8,504	5,194
228.86	8,743	5,366
228.88	8,982	5,543
228.90	9,221	5,725
228.92	9,460	5,912
228.94	9,699	6,104
228.96	9,938	6,300
228.98	10,177	6,501
229.00	**10,416**	**6,707**

Stage-Area-Storage for Pond 301: Infiltration 1

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
227.00	500	0
227.02	507	10
227.04	513	20
227.06	520	31
227.08	526	41
227.10	532	52
227.12	539	62
227.14	545	73
227.16	552	84
227.18	559	95
227.20	565	106
227.22	571	118
227.24	578	129
227.26	584	141
227.28	591	153
227.30	598	165
227.32	604	177
227.34	611	189
227.36	617	201
227.38	623	213
227.40	630	226
227.42	636	239
227.44	643	251
227.46	650	264
227.48	656	277
227.50	663	291
227.52	669	304
227.54	675	317
227.56	682	331
227.58	689	345
227.60	695	358
227.62	702	372
227.64	708	387
227.66	714	401
227.68	721	415
227.70	727	430
227.72	734	444
227.74	741	459
227.76	747	474
227.78	754	489
227.80	760	504
227.82	766	519
227.84	773	535
227.86	780	550
227.88	786	566
227.90	793	582
227.92	799	598
227.94	805	614
227.96	812	630
227.98	818	646
228.00	825	663
228.02	831	679
228.04	837	696
228.06	843	713
228.08	849	729
228.10	855	746
228.12	861	764
228.14	867	781
228.16	873	798
228.18	879	816
228.20	885	833
228.22	891	851
228.24	897	869
228.26	903	887
228.28	910	905
228.30	916	924
228.32	923	942
228.34	929	960
228.36	936	979
228.38	942	998
228.40	949	1,017
228.42	956	1,036
228.44	962	1,055
228.46	969	1,074
228.48	975	1,094
228.50	982	1,113
228.52	988	1,133
228.54	995	1,153
228.56	1,001	1,173
228.58	1,008	1,193
228.60	1,014	1,213
228.62	1,021	1,233
228.64	1,027	1,254
228.66	1,034	1,275
228.68	1,040	1,295
228.70	1,047	1,316
228.72	1,054	1,337
228.74	1,060	1,358
228.76	1,067	1,380
228.78	1,073	1,401
228.80	1,080	1,423
228.82	1,086	1,444
228.84	1,093	1,466
228.86	1,099	1,488
228.88	1,106	1,510
228.90	1,112	1,532
228.92	1,119	1,554
228.94	1,125	1,577
228.96	1,132	1,599
228.98	1,138	1,622
229.00	**1,145**	**1,645**

Table 3-1: Average annual distinct phosphorus load (P Load) export rates for use in estimating phosphorus load reduction credits the MA MS4 Permit

Phosphorus Source Category by Land Use	Land Surface Cover	P Load Export Rate, lbs/acre/year	P Load Export Rate, kg/ha/yr
Commercial (Com) and Industrial (Ind)	Directly connected impervious	1.78	2.0
	Pervious	See* DevPERV	See* DevPERV
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	2.6
	Pervious	See* DevPERV	See* DevPERV
Medium -Density Residential (MDR)	Directly connected impervious	1.96	2.2
	Pervious	See* DevPERV	See* DevPERV
Low Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Highway (HWY)	Directly connected impervious	1.34	1.5
	Pervious	See* DevPERV	See* DevPERV
Forest (For)	Directly connected impervious	1.52	1.7
	Pervious	0.13	0.13
Open Land (Open)	Directly connected impervious	1.52	1.7
	Pervious	See* DevPERV	See* DevPERV
Agriculture (Ag)	Directly connected impervious	1.52	1.7
	Pervious	0.45	0.5
*Developed Land Pervious (DevPERV)- Hydrologic Soil Group A	Pervious	0.03	0.03
*Developed Land Pervious (DevPERV)- Hydrologic Soil Group B	Pervious	0.12	0.13
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group C	Pervious	0.21	0.24
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group C/D	Pervious	0.29	0.33
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group D	Pervious	0.37	0.41

VMD MONARCH DRIVE INDUSTRIAL DEVELOPMENT

PHOSPHORUS REMOVAL CALCULATIONS

Basin Number	IMPERVIOUS				Soil Type	Forest/ woods					Lawn/Landscaped Areas					Total P	100% Reduction of Total P
	S.F	Ac.	P load Chart 3-1	Rainfall Depth for 100%		S.F	Ac.	P load Chart 3-1	Runoff depth Chart 3-3	Runoff Volume	S.F	Ac.	P load Chart 3-1	Runoff depth Chart 3-3	Runoff Volume		
Basin 1	132,540	3.043	5.96	1.50	A	0	0.000	0.00	0.14	0	27,585	0.633	0.02	0.14	322		
					B	0	0.000	0.00	0.22	0	0	0.000	0.00	0.22	0		
					C	0	0.000	0.00	0.69	0	0	0.000	0.00	0.69	0		
					D		0.000	0.00	0.89	0	0	0.000	0.00	0.89	0		
Totals		3.043	5.96			0	0.000	0.00		0	27585	0.633	0.02		322	5.98	5.98
											PA Total Runoff Volume				322		

Basin Number	IMPERVIOUS				Soil Type	Forest/ woods					Lawn/Landscaped Areas					Total P	100% Reduction of Total P
	S.F	Ac.	P load Chart 3-1	Rainfall Depth for 100%		S.F	Ac.	P load Chart 3-1	Runoff depth Chart 3-3	Runoff Volume	S.F	Ac.	P load Chart 3-1	Runoff depth Chart 3-3	Runoff Volume		
Basin 2 and 3	27,160	0.624	1.22	1.50	A	0	0.000	0.00	0.14	0	33,305	0.765	0.02	0.14	389		
					B	0	0.000	0.00	0.22	0	0	0.000	0.00	0.22	0		
					C	0	0.000	0.00	0.69	0	0	0.000	0.00	0.69	0		
					D		0.000	0.00	0.89	0	0	0.000	0.00	0.89	0		
Totals		0.624	1.22			0	0.000	0.00		0	33305	0.765	0.02		389	1.25	1.25
											PA Total Runoff Volume				389		

Basin Number	IMPERVIOUS				Soil Type	Forest/ woods					Lawn/Landscaped Areas					Total P	100% Reduction of Total P
	S.F	Ac.	P load Chart 3-1	Rainfall Depth for 100%		S.F	Ac.	P load Chart 3-1	Runoff depth Chart 3-3	Runoff Volume	S.F	Ac.	P load Chart 3-1	Runoff depth Chart 3-3	Runoff Volume		
Infiltration Trench and Chambers	22,330	0.513	1.00	1.50	A	0	0.000	0.00	0.14	0	3,845	0.088	0.00	0.14	45		
					B	0	0.000	0.00	0.22	0	0	0.000	0.00	0.22	0		
					C	0	0.000	0.00	0.69	0	0	0.000	0.00	0.69	0		
					D		0.000	0.00	0.89	0	0	0.000	0.00	0.89	0		
Totals		0.513	1.00			0	0.000	0.00		0	3845	0.088	0.00		45	1.01	1.01
											PA Total Runoff Volume				45		8.24

PHOSPHORUS LOAD FOR ALL DISTURBED AREAS OF SITE

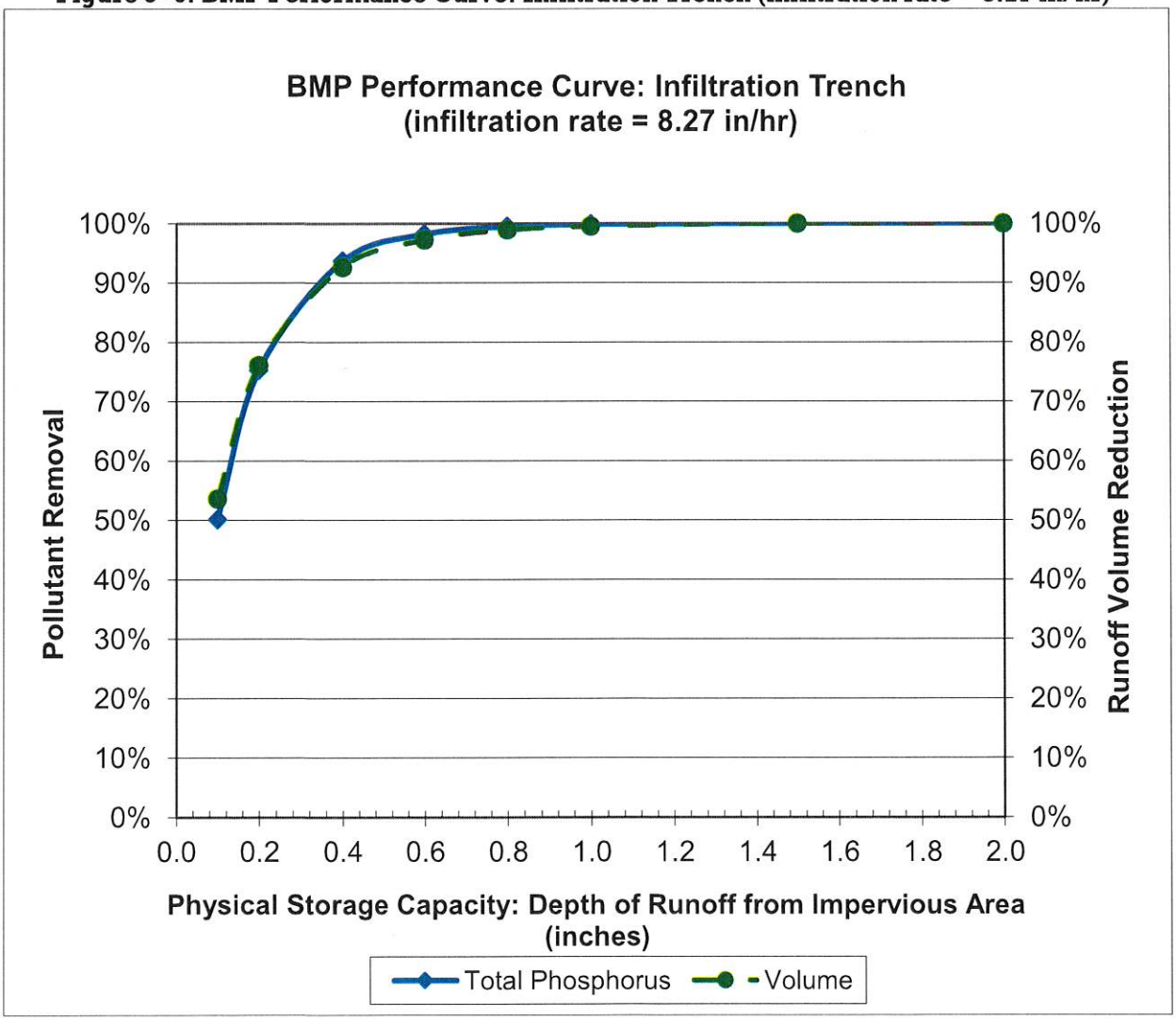
Basin Number	IMPERVIOUS			Soil Type	Forest			Lawn/Landscaped Areas			Total P	Total P Reduction	Percent of Reduction
	S.F	Ac.	P load		S.F	Ac.	P load	S.F	Ac.	P load			
Entire Site	203545	4.673	9.16	A	0	0.000	0.00	87400	2.006	0.06			
				B	0	0.00	0.00	0	0.000	0.00			
				C	0	0.00	0.00	0	0.000	0.00			
				D	0	0.00	0.00	0	0.000	0.00			
Totals		4.673	9.16		0		0.00	87400	2.006	0.06	9.22	8.24	89.38

* Lawn/landscaped areas includes all areas included in the HydroCAD calculations (75,400 s.f.) plus an estimated 12.000 s.f. representing the wooded area where the septic system leaching areas will be installed. It should be noted that this Percentage of Reduction is a reduction of the post developed site without BMPs versus with the BMPs.

Table 3- 9: Infiltration Trench (8.27 in/hr) BMP Performance Table

Infiltration Trench (8.27 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	53.6%	76.1%	92.6%	97.2%	98.9%	99.5%	100.0%	100.0%
Cumulative Phosphorus Load Reduction	50%	75%	94%	98%	99%	100%	100%	100%

Figure 3- 6: BMP Performance Curve: Infiltration Trench (infiltration rate = 8.27 in/hr)



Flow Chart 3: Method to determine the design storage volume of a BMP to reach a known P load reduction when both impervious and pervious drainage areas are present.

1) Determine the desired cumulative phosphorus load reduction target (P_{target}) in percentage for the structural BMP;
2) Characterize the contributing drainage area to the structural BMP by identifying the following information for the impervious and pervious surfaces:
   Impervious area (IA) - Area (acre) and land use (e.g., commercial)

   Pervious area (PA) – Area (acre) and runoff depths based on hydrologic soil group (HSG) and rainfall depth. Table 3-3 provides values of runoff depth from pervious areas for various rainfall depths and HSGs. Soils are assigned to an HSG on the basis of their permeability. HSG A is the most permeable, and HSG D is the least permeable. HSG categories for pervious areas in the drainage area shall be estimated by consulting local soil surveys prepared by the National Resource Conservation Service (NRCS) or by a storm water professional evaluating soil testing results from the drainage area. If the HSG condition is not known, a HSG D soil condition should be assumed.

Table 3- 3: Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups (HSGs)

Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups					
Rainfall Depth, Inches	Runoff Depth, inches				
	Pervious HSG A	Pervious HSG B	Pervious HSG C	Pervious HSG C/D	Pervious HSG D
0.10	0.00	0.00	0.00	0.00	0.00
0.20	0.00	0.00	0.01	0.02	0.02
0.40	0.00	0.00	0.03	0.05	0.06
0.50	0.00	0.01	0.05	0.07	0.09
0.60	0.01	0.02	0.06	0.09	0.11
0.80	0.02	0.03	0.09	0.13	0.16
1.00	0.03	0.04	0.12	0.17	0.21
1.20	0.04	0.05	0.14	0.27	0.39
1.50	0.08	0.11	0.39	0.55	0.72
2.00	0.14	0.22	0.69	0.89	1.08

Notes: Runoff depths derived from combination of volumetric runoff coefficients from Table 5 of *Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices*, (Pitt, 1999), and using the Stormwater Management Model (SWMM) in continuous model mode for hourly precipitation data for Boston, MA, 1998-2002.

3) Determine the structural BMP type (e.g., infiltration trench, gravel wetland). For infiltration systems, determine the appropriate infiltration rate for the location of the BMP in the Watershed;
4) Using the cumulative phosphorus removal performance curve for the selected structural BMP, determine the storage volume capacity of the BMP in inches needed to treat runoff from the contributing impervious area (BMP-Volume $_{IA\text{-}in}$);

Table 3- 15: Infiltration Basin (8.27 in/hr) BMP Performance Table

Infiltration Basin (8.27 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	54.6%	77.2%	93.4%	97.5%	99.0%	99.6%	100.0%	100.0%
Cumulative Phosphorus Load Reduction	59%	81%	96%	99%	100%	100%	100%	100%

Figure 3- 12: BMP Performance Curve: Infiltration Basin (infiltration rate = 8.27 in/hr)

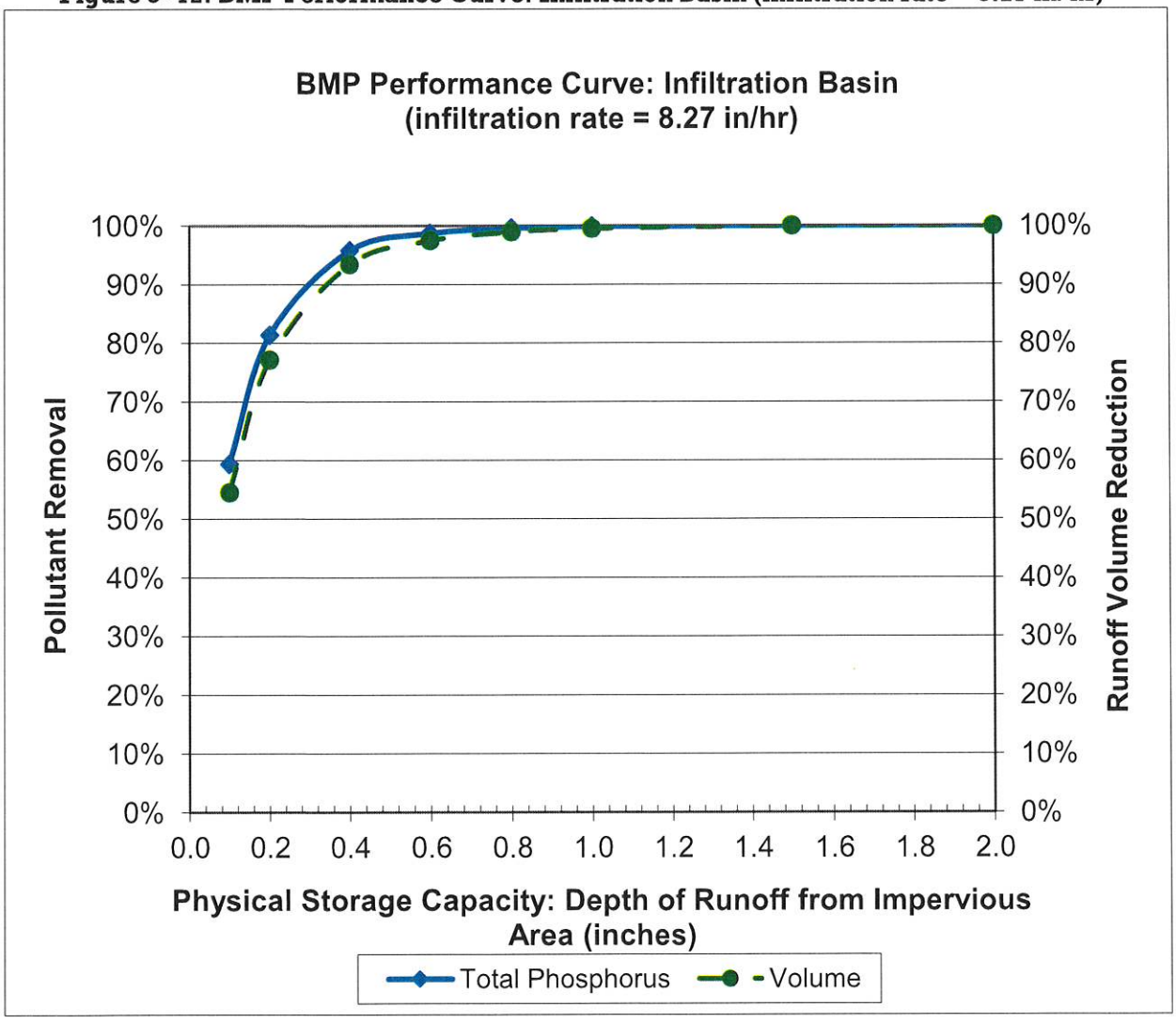


Table 3- 16: Biofiltration BMP Performance Table

Biofiltration BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	19%	34%	53%	64%	71%	76%	84%	89%

Figure 3- 13: BMP Performance Curve: Biofiltration

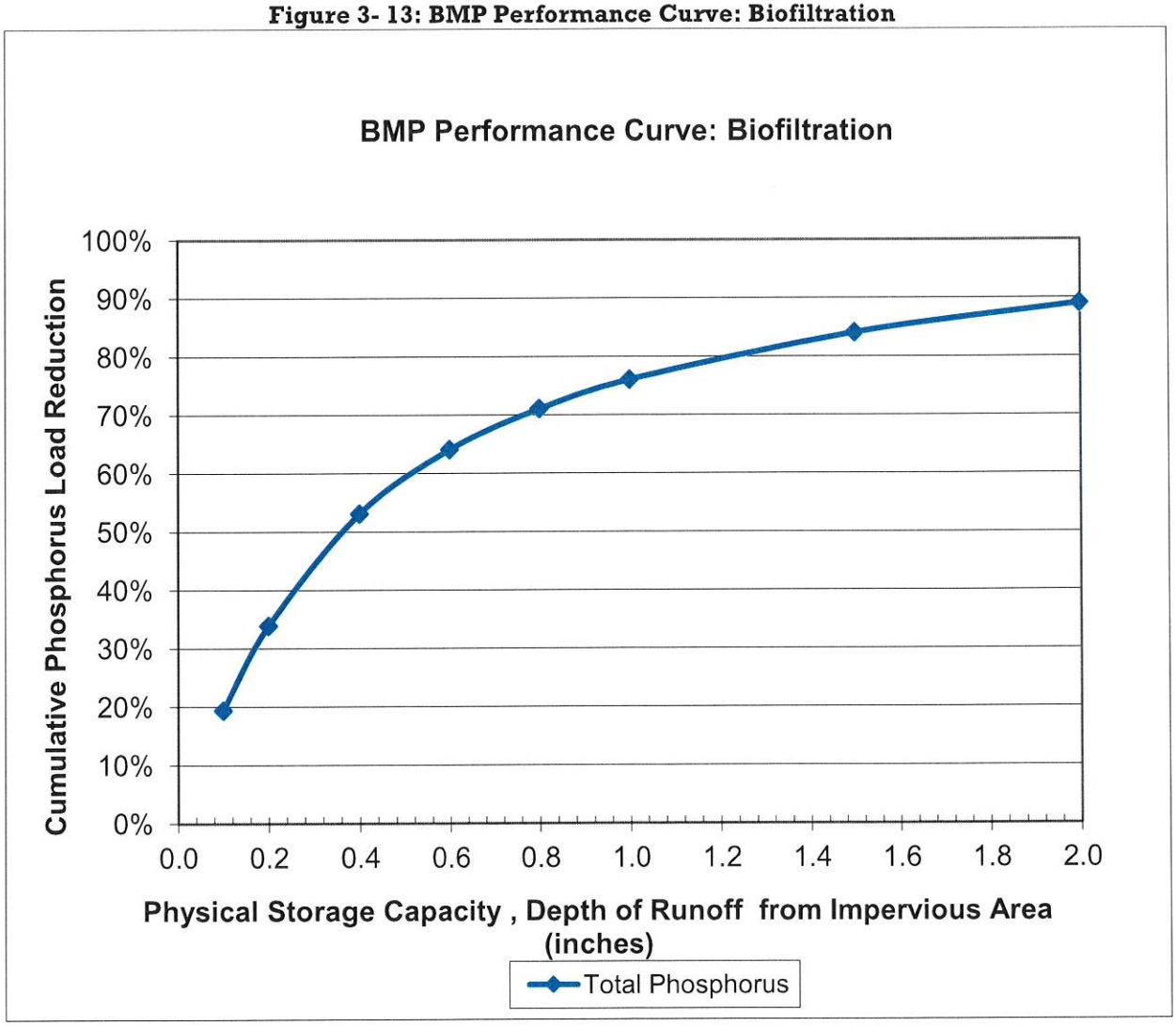


Table 3-30 Method for determining stormwater control design volume (DSV) (i.e., capacity) using Long-term cumulative performance curves

Stormwater Control Type	Description	Applicable Structural Stormwater Control Performance Curve	Equation for calculating Design Storage Capacity for Estimating Cumulative Reductions using Performances Curves
Infiltration Trench	Provides temporary storage of runoff using the void spaces within the soil/sand/gravel mixture that is used to backfill the trench for subsequent infiltration into the surrounding sub-soils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = void space volumes of gravel and sand layers DSV = (L x W x D_{stone} x n_{stone})+ (L x W x D_{sand} x n_{sand})
Subsurface Infiltration	Provides temporary storage of runoff using the combination of storage structures (e.g., galleys, chambers, pipes, etc.) and void spaces within the soil/sand/gravel mixture that is used to backfill the system for subsequent infiltration into the surrounding sub-soils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Water storage volume of storage units and void space volumes of backfill materials. Example for subsurface galleys backfilled with washed stone: DSV = (L x W x D)$_{galley}$ + (L x W x D_{stone} x n_{stone})
Surface Infiltration	Provides temporary storage of runoff through surface ponding storage structures (e.g., basin or swale) for subsequent infiltration into the underlying soils.	Infiltration Basin (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Water volume of storage structure before bypass. Example for linear trapezoidal vegetated swale DSV = (L x ((W_{bottom}+$W_{top@Dmax}$)/2) x D)
Rain Garden/Bio-retention (no underdrains)	Provides temporary storage of runoff through surface ponding and possibly void spaces within the soil/sand/gravel mixture that is used to filter runoff prior to infiltration into underlying soils.	Infiltration Basin (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Ponding water storage volume and void space volumes of soil filter media. Example for raingarden : DSV = (A_{pond} x D_{pond}) + (A_{soil} x D_{soil} x $n_{soil\ mix}$)
Tree Filter (no underdrain)	Provides temporary storage of runoff through surface ponding and void spaces within the soil/sand/gravel mixture that is used to filter runoff prior to infiltration into underlying soils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Ponding water storage volume and void space volumes of soil filter media. DSV = (L x W x $D_{ponding}$) + (L x W x D_{soil} x $n_{soil\ mix}$)
Bio-Filtration (w/underdrain)	Provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity includes void spaces in the filter media and temporary ponding at the surface. After runoff has passed through the filter media it is collected by an under-drain pipe for discharge. Manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results.	Bio-filtration	DSV = Ponding water storage volume and void space volume of soil filter media. Example of a linear biofilter: DSV = (L x W x $D_{ponding}$)+ (L x W x D_{soil} x n_{soil})
Gravel Wetland	Based on design by the UNH Stormwater Center (UNHSC). Provides temporary surface ponding storage of runoff in a vegetated wetland cell that is eventually routed to an underlying saturated gravel internal storage reservoir (ISR) for nitrogen treatment. Outflow is controlled by an elevated orifice that has its invert elevation equal to the top of the ISR layer and provides a retention time of at least 24 hours.	Gravel Wetland	DSV = pretreatment volume + ponding volume + void space volume of gravel ISR. DSV = ($A_{pretreatment}$ x $D_{preTreatment}$)+ ($A_{wetland}$ x $D_{ponding}$)+ (A_{ISR} x D_{gravel} x n_{gravel})
Porous Pavement with subsurface infiltration	Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces of a subsurface gravel reservoir prior to infiltration into subsoils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = void space volumes of gravel layer DSV = (L x W x D_{stone} x n_{stone})
Porous pavement w/ impermeable underliner w/underdrain	Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces prior to discharge by way of an underdrain.	Porous Pavement	Depth of Filter Course = D_{FC}
Wet Pond	Provides treatment of runoff through routing through permanent pool.	Wet Pond	DSV= Permanent pool volume prior to high flow bypass DSV=A_{pond} x D_{pond} (does not include pretreatment volume)
Extended Dry Detention Basin	Provides temporary detention storage for the design storage volume to drain in 24 hours through multiple out let controls.	Dry Pond	DSV= Ponding volume prior to high flow bypass DSV=A_{pond} x D_{pond} (does not include pretreatment volume)
Dry Water Quality Swale/Grass Swale	Based on MA design standards. Provides temporary surface ponding storage of runoff in an open vegetated channel through permeable check dams. Treatment is provided by filtering of runoff by vegetation and check dams and infiltration into subsurface soils.	Grass swale	DSV = Volume of swale at full design depth DSV=Lswale x Aswale
Definitions: DSV= Design Storage Volume = physical storage capacity to hold water; VSV = Void Space Volume; **L** = length, **W** = width, **D** = depth at design capacity before bypass, **n** = porosity fill material, **A**= average surface area for calculating volume; **Infiltration rate** = saturated soil hydraulic conductivity			

Supporting Data – CDS TSS Removal Calculations

Hydrodynamic Separation Product Calculator

Littleton Warehouse 1

Stormwater Treatment Unit 1

CDS 2015-4

Project Information					
Project Name	Littleton Warehouse 1			**Option #**	A
Country	UNITED_STATES	**State**	Massachusetts	**City**	Littleton

Contact Information			
First Name	Patrick	**Last Name**	Burke
Company	Places Associates, Inc.	**Phone #**	978-486-0334
Email	pburke@placesassociates.com		

Design Criteria					
Site Designation	Stormwater Treatment Unit 1			**Sizing Method**	Net Annual
Screening Required?	No	**Drainage Area (ac)**	0.60	**Peak Flow (cfs)**	3.59
Groundwater Depth (ft)	5 - 10	**Pipe Invert Depth (ft)**	0 - 5	**Bedrock Depth (ft)**	>15
Multiple Inlets?	No	**Grate Inlet Required?**	No	**Pipe Size (in)**	12.00
Required Particle Size Distribution?	No	**90° between two inlets?**	N/A	**180° between inlet and outlet?**	No
Runoff Coefficient	0.81	**Rainfall Station**	71 - Birch Hill Dam, MA	**TC (Min)**	6

Treatment Selection					
Treatment Unit	CDS	**System Model**	2015-4		
Target Removal	80%	**Particle Size Distribution (PSD)**	125	**Predicted Net Annual Removal**	96.09%

CONTECH ENGINEERED SOLUTIONS

Hydrodynamic Separation Product Calculator

Littleton Warehouse 1

Stormwater Treatment Unit 1

CDS 2015-4

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION BASED ON THE RATIONAL RAINFALL METHOD								
Rainfall Intensity[1] (in/hr)	% Rainfall Volume[1]	Cumulative Rainfall Volume	Rainfall Volume Treated	Total Flowrate (cfs)	Treated Flowrate (cfs)	Operating Rate (%)	Removal Efficiency (%)	Incremental Removal (%)
0.0800	37.59%	37.59%	37.59%	0.0389	0.0389	5.56%	100.00%	37.59%
0.1600	22.64%	60.23%	22.64%	0.0778	0.0778	11.11%	99.19%	22.46%
0.2400	11.89%	72.12%	11.89%	0.1166	0.1166	16.66%	98.08%	11.66%
0.3200	7.58%	79.70%	7.58%	0.1555	0.1555	22.21%	96.97%	7.35%
0.4000	4.35%	84.05%	4.35%	0.1944	0.1944	27.77%	95.85%	4.17%
0.4800	2.35%	86.40%	2.35%	0.2333	0.2333	33.33%	94.74%	2.23%
0.5600	1.79%	88.19%	1.79%	0.2722	0.2722	38.89%	93.63%	1.68%
0.6400	1.37%	89.56%	1.37%	0.3110	0.3110	44.43%	92.52%	1.27%
0.7200	0.87%	90.43%	0.87%	0.3499	0.3499	49.99%	91.41%	0.80%
0.8000	1.16%	91.59%	1.16%	0.3888	0.3888	55.54%	90.30%	1.05%
0.8800	1.49%	93.08%	1.49%	0.4277	0.4277	61.10%	89.18%	1.33%
0.9600	0.93%	94.01%	0.93%	0.4666	0.4666	66.66%	88.07%	0.82%
1.0400	0.38%	94.39%	0.38%	0.5054	0.5054	72.20%	86.96%	0.33%
1.1200	0.41%	94.80%	0.41%	0.5443	0.5443	77.76%	85.85%	0.35%
1.2000	0.58%	95.38%	0.58%	0.5832	0.5832	83.31%	84.74%	0.49%
1.2800	0.31%	95.69%	0.31%	0.6221	0.6221	88.87%	83.63%	0.26%
1.3600	0.17%	95.86%	0.17%	0.6610	0.6610	94.43%	82.51%	0.14%
1.4400	0.88%	96.74%	0.88%	0.6998	0.6998	99.97%	81.41%	0.72%
1.5200	0.55%	97.29%	0.52%	0.7387	0.7000	100.00%	77.14%	0.42%
1.6000	0.40%	97.69%	0.36%	0.7776	0.7000	100.00%	73.28%	0.29%
1.8000	0.20%	97.89%	0.16%	0.8748	0.7000	100.00%	65.13%	0.13%
2.0000	0.94%	98.83%	0.68%	0.9720	0.7000	100.00%	58.62%	0.55%
								96.09%
							Removal Efficiency Adjustment[2] =	
							Predicted % Annual Rainfall Treated =	98.46%
							Predicted Net Annual Load Removal Efficiency =	96.09%

1 - Based on 13 years of 15 minute precipitation data for Station 0666, Birch Hill Dam, Worcester County, MA

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

Hydrodynamic Separation Product Calculator

Littleton Warehouse 1

Stormwater Treatment Unit 2

CDS 2015-4

Project Information					
Project Name	Littleton Warehouse 1			**Option #**	A
Country	UNITED_STATES	**State**	Massachusetts	**City**	Littleton

Contact Information			
First Name	Patrick	**Last Name**	Burke
Company	Places Associates, Inc.	**Phone #**	978-486-0334
Email	pburke@placesassociates.com		

Design Criteria					
Site Designation	Stormwater Treatment Unit 2			**Sizing Method**	Net Annual
Screening Required?	No	**Drainage Area (ac)**	0.43	**Peak Flow (cfs)**	3.19
Groundwater Depth (ft)	5 - 10	**Pipe Invert Depth (ft)**	5 - 10	**Bedrock Depth (ft)**	>15
Multiple Inlets?	No	**Grate Inlet Required?**	Yes	**Pipe Size (in)**	12.00
Required Particle Size Distribution?	No	**90° between two inlets?**	N/A	**180° between inlet and outlet?**	No
Runoff Coefficient	0.90	**Rainfall Station**	71 - Birch Hill Dam, MA	**TC (Min)**	6

Treatment Selection					
Treatment Unit	CDS	**System Model**	2015-4		
Target Removal	80%	**Particle Size Distribution (PSD)**	125	**Predicted Net Annual Removal**	96.90%

CONTECH ENGINEERED SOLUTIONS

Hydrodynamic Separation Product Calculator

Littleton Warehouse 1

Stormwater Treatment Unit 2

CDS 2015-4

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION BASED ON THE RATIONAL RAINFALL METHOD								
Rainfall Intensity[1] (in/hr)	% Rainfall Volume[1]	Cumulative Rainfall Volume	Rainfall Volume Treated	Total Flowrate (cfs)	Treated Flowrate (cfs)	Operating Rate (%)	Removal Efficiency (%)	Incremental Removal (%)
0.0800	37.59%	37.59%	37.59%	0.0310	0.0310	4.43%	100.00%	37.59%
0.1600	22.64%	60.23%	22.64%	0.0619	0.0619	8.84%	99.64%	22.56%
0.2400	11.89%	72.12%	11.89%	0.0929	0.0929	13.27%	98.75%	11.74%
0.3200	7.58%	79.70%	7.58%	0.1238	0.1238	17.69%	97.87%	7.42%
0.4000	4.35%	84.05%	4.35%	0.1548	0.1548	22.11%	96.99%	4.22%
0.4800	2.35%	86.40%	2.35%	0.1858	0.1858	26.54%	96.10%	2.26%
0.5600	1.79%	88.19%	1.79%	0.2167	0.2167	30.96%	95.21%	1.70%
0.6400	1.37%	89.56%	1.37%	0.2477	0.2477	35.39%	94.33%	1.29%
0.7200	0.87%	90.43%	0.87%	0.2786	0.2786	39.80%	93.45%	0.81%
0.8000	1.16%	91.59%	1.16%	0.3096	0.3096	44.23%	92.56%	1.07%
0.8800	1.49%	93.08%	1.49%	0.3406	0.3406	48.66%	91.67%	1.37%
0.9600	0.93%	94.01%	0.93%	0.3715	0.3715	53.07%	90.79%	0.84%
1.0400	0.38%	94.39%	0.38%	0.4025	0.4025	57.50%	89.90%	0.34%
1.1200	0.41%	94.80%	0.41%	0.4334	0.4334	61.91%	89.02%	0.36%
1.2000	0.58%	95.38%	0.58%	0.4644	0.4644	66.34%	88.14%	0.51%
1.2800	0.31%	95.69%	0.31%	0.4954	0.4954	70.77%	87.25%	0.27%
1.3600	0.17%	95.86%	0.17%	0.5263	0.5263	75.19%	86.36%	0.15%
1.4400	0.88%	96.74%	0.88%	0.5573	0.5573	79.61%	85.48%	0.75%
1.5200	0.55%	97.29%	0.55%	0.5882	0.5882	84.03%	84.60%	0.47%
1.6000	0.40%	97.69%	0.40%	0.6192	0.6192	88.46%	83.71%	0.33%
1.8000	0.20%	97.89%	0.20%	0.6966	0.6966	99.51%	81.50%	0.16%
2.0000	0.94%	98.83%	0.85%	0.7740	0.7000	100.00%	73.62%	0.69%
								96.90%
							Removal Efficiency Adjustment[2] =	
							Predicted % Annual Rainfall Treated =	98.74%
							Predicted Net Annual Load Removal Efficiency =	96.90%

1 - Based on 13 years of 15 minute precipitation data for Station 0666, Birch Hill Dam, Worcester County, MA

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

Hydrodynamic Separation Product Calculator

Littleton Warehouse 1

Stormwater Treatment Unit 3

CDS 2015-4

Project Information					
Project Name	Littleton Warehouse 1			**Option #**	A
Country	UNITED_STATES	**State**	Massachusetts	**City**	Littleton

Contact Information			
First Name	Patrick	**Last Name**	Burke
Company	Places Associates, Inc.	**Phone #**	978-486-0334
Email	pburke@placesassociates.com		

Design Criteria					
Site Designation	Stormwater Treatment Unit 3			**Sizing Method**	Net Annual
Screening Required?	No	**Drainage Area (ac)**	0.16	**Peak Flow (cfs)**	1.14
Groundwater Depth (ft)	5 - 10	**Pipe Invert Depth (ft)**	0 - 5	**Bedrock Depth (ft)**	>15
Multiple Inlets?	No	**Grate Inlet Required?**	No	**Pipe Size (in)**	12.00
Required Particle Size Distribution?	No	**90° between two inlets?**	N/A	**180° between inlet and outlet?**	No
Runoff Coefficient	0.90	**Rainfall Station**	71 - Birch Hill Dam, MA	**TC (Min)**	6

Treatment Selection					
Treatment Unit	CDS	**System Model**	2015-4		
Target Removal	80%	**Particle Size Distribution (PSD)**	125	**Predicted Net Annual Removal**	98.47%

CONTECH ENGINEERED SOLUTIONS

Hydrodynamic Separation Product Calculator

Littleton Warehouse 1

Stormwater Treatment Unit 3

CDS 2015-4

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION BASED ON THE RATIONAL RAINFALL METHOD								
Rainfall Intensity[1] (in/hr)	% Rainfall Volume[1]	Cumulative Rainfall Volume	Rainfall Volume Treated	Total Flowrate (cfs)	Treated Flowrate (cfs)	Operating Rate (%)	Removal Efficiency (%)	Incremental Removal (%)
0.0800	37.59%	37.59%	37.59%	0.0115	0.0115	1.64%	100.00%	37.59%
0.1600	22.64%	60.23%	22.64%	0.0230	0.0230	3.29%	100.00%	22.64%
0.2400	11.89%	72.12%	11.89%	0.0346	0.0346	4.94%	100.00%	11.89%
0.3200	7.58%	79.70%	7.58%	0.0461	0.0461	6.59%	100.00%	7.58%
0.4000	4.35%	84.05%	4.35%	0.0576	0.0576	8.23%	99.76%	4.34%
0.4800	2.35%	86.40%	2.35%	0.0691	0.0691	9.87%	99.44%	2.34%
0.5600	1.79%	88.19%	1.79%	0.0806	0.0806	11.51%	99.11%	1.77%
0.6400	1.37%	89.56%	1.37%	0.0922	0.0922	13.17%	98.77%	1.35%
0.7200	0.87%	90.43%	0.87%	0.1037	0.1037	14.81%	98.45%	0.86%
0.8000	1.16%	91.59%	1.16%	0.1152	0.1152	16.46%	98.12%	1.14%
0.8800	1.49%	93.08%	1.49%	0.1267	0.1267	18.10%	97.79%	1.46%
0.9600	0.93%	94.01%	0.93%	0.1382	0.1382	19.74%	97.46%	0.91%
1.0400	0.38%	94.39%	0.38%	0.1498	0.1498	21.40%	97.13%	0.37%
1.1200	0.41%	94.80%	0.41%	0.1613	0.1613	23.04%	96.80%	0.40%
1.2000	0.58%	95.38%	0.58%	0.1728	0.1728	24.69%	96.47%	0.56%
1.2800	0.31%	95.69%	0.31%	0.1843	0.1843	26.33%	96.14%	0.30%
1.3600	0.17%	95.86%	0.17%	0.1958	0.1958	27.97%	95.81%	0.16%
1.4400	0.88%	96.74%	0.88%	0.2074	0.2074	29.63%	95.48%	0.84%
1.5200	0.55%	97.29%	0.55%	0.2189	0.2189	31.27%	95.15%	0.52%
1.6000	0.40%	97.69%	0.40%	0.2304	0.2304	32.91%	94.82%	0.38%
1.8000	0.20%	97.89%	0.20%	0.2592	0.2592	37.03%	94.00%	0.19%
2.0000	0.94%	98.83%	0.94%	0.2880	0.2880	41.14%	93.18%	0.88%
								98.47%
							Removal Efficiency Adjustment[2] =	
							Predicted % Annual Rainfall Treated =	98.83%
							Predicted Net Annual Load Removal Efficiency =	98.47%

1 - Based on 13 years of 15 minute precipitation data for Station 0666, Birch Hill Dam, Worcester County, MA

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

MADEP Stormwater Checklist

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature

Susan Carter 6/27/22

Signature and Date

Checklist

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

- [X] 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:

- [X] No disturbance to any Wetland Resource Areas
- [ ] Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- [ ] Reduced Impervious Area (Redevelopment Only)
- [X] 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)
- [X] Treebox Filter
- [ ] Water Quality Swale
- [ ] Grass Channel
- [ ] Green Roof
- [ ] Other (describe): _____

Standard 1: No New Untreated Discharges

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

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

☐ is within the Zone II or Interim Wellhead Protection Area

☒ is near or to other critical areas

☒ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)

☐ involves runoff from land uses with higher potential pollutant loads.

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist for 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 for 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.

Stormwater Operation and Maintenance Plan

Stormwater Operation and Maintenance Plan - Long Term Pollution Prevention

Ongoing maintenance is required for the proper function of the stormwater management system allowing the system prevent pollution for the long term. This document provides a guideline for this work and allows for record keeping.

Stormwater Management System Owner: To be determined

_____
Signature/date

Party Responsible for Maintenance: To be determined

_____
Signature/date

Snow Removal

Snow removal from parking areas will be the responsibility of the property owner.

Public Safety Features

The site has been designed with sidewalks and lighting to allow for safe movement throughout the site.

Preliminary Stormwater O&M Maintenance Budget

Inspection and maintenance = $1,250 x 4 times per year = $5,000±

Site Specific BMP Maintenance Plans
(Reference MADEP Volume 2, Chapter – Structural BMP Specifications for the Massachusetts Stormwater Handbook)

Routine Maintenance

Routine maintenance of lawns, gardens, and other landscaped areas shall occur as necessary to maintain the property in a neat and orderly fashion. Clippings and/or mulch shall not be washed into the drainage infrastructure.

Catch Basins and Manholes

Regular maintenance is essential. Deep sump catch basins remain effective at removing pollutants only if they are cleaned out frequently. Once 50% of the sump volume is filled, the catch basin may not be able to retain additional sediment.
Inspect or clean deep sumps at least four times per year and at the end of the foliage and snow removal seasons. Sediments must also be removed four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. Clamshell buckets are typically used to remove sediment; however, vacuum trucks are preferable as they remove more trapped sediment than clamshells. Vacuuming is also a speedier process and is less likely to damage the hood within the deep sump catch basin.

Trench Drains

Inspect trench drains four times per year. Remove sediments each spring and when accumulation is 3 inches deep. Inspect grates and repair or replace, as necessary.

Infiltration Basins

Inspect and complete preventive maintenance at least twice a year, and after every time drainage discharges through the emergency spillway. Inspect the pretreatment as required. Once the basin is in use, inspect it after every major storm for the first few months to ensure it is stabilized and functioning properly and if necessary, take corrective action. Note how long water remains standing in the basin after a storm; standing water within the basin 48 to 72 hours after a storm indicates the infiltration capacity may have been overestimated. If the ponding is due to clogging, immediately address the reasons for the clogging (such as upland sediment erosion, excessive compaction of soils, or low spots). Thereafter, inspect the infiltration basin at least twice per year. Important items to check during the inspection include:

- Signs of differential settlement
- Cracking, Erosion
- Leakage in the embankments
- Tree growth on the embankments
- Condition of riprap
- Sediment accumulation
- The health of the turf.

At least twice a year, mow the buffer area, side slopes, and basin bottom if grassed. Remove grass clippings and accumulated organic matter to prevent an impervious organic mat from forming. Remove trash and debris at the same time. Use deep tilling to break up clogged surfaces and revegetate immediately. Remove sediment from the basin as necessary but wait until the floor of the basin is thoroughly dry. Use light equipment to remove the top layer to not compact the underlying

soil. Deeply till the remaining soil and revegetate as soon as possible. Inspect and clean pretreatment devices per O&M.

Infiltration Chambers

Follow manufacturer's recommended Inspection and maintenance program. Inspect infiltration chambers at least once per year to ensure that the basins are operating as intended. Inspect infiltration chambers during and after major storms to determine if the chambers are meeting the expected detention times. Examine the outlet structure for evidence of clogging or outflow release velocities that are greater than design flow. Potential problems that should be checked include: subsidence, erosion, cracking, or tree growth on or near the chambers; sediment accumulation around the outlet; inadequacy of the inlet/outlet channel erosion control measures; and erosion or sedimentation at the inlets. Make any necessary repairs immediately. During inspections, note any changes to the infiltration chambers or the contributing watershed, because these could affect chamber performance. Also remove trash and debris at this time. Remove sediment from the in chambers as necessary, but at least once every 5 years. Providing an on-site sediment disposal area will reduce the overall sediment removal costs.

Tree Box Filters

Inspect and complete preventive maintenance quarterly during first year following construction and after every major storm in the first few months. Important items to inspect:

- Check to ensure the filter surface remains well draining after storms. The system should drain completely within 72 hours.
  If filter bed is clogged, draining poorly, or standing water covers more than 50% of the surface 48 hours after a precipitation event, remove top few inches of discolored material. Till, or rake remaining material as needed. Replace mulch as necessary.
- Check inlets and outlets for leaves and debris.
  Rake in and around the system to clear it of debris. Also, clear the inlet and overflow if obstructed.
- Check for animal burrows and short circuiting the system.
  Soil erosion from short circuiting or animal boroughs should be repaired when they occur. The holes should be filled and lightly compacted.
- Inspect inlets and outlets to ensure good condition and no evidence of deterioration. Check to see if high-flow bypass is functioning.
  Repair or replace any damaged structural parts, inlets, outlets, sidewalls.
- Check health of trees. Tree is stable and roots are not exposed.
- Keep a record of inspections.

Stormwater Treatment Units

Much like the catch basins, regular maintenance of the water quality units is essential. The maintenance of these units begins immediately at post-construction prior to putting the unit into service. During the first year of operation, the units should be inspected quarterly in order to determine the rate of accumulation of sediment and oils. In subsequent years, the units can be inspected at a frequency determined by the accumulation rate of sediment and oils, but in no cases should the inspection frequency exceed six months.

Inspect and complete preventive maintenance in accordance with manufacturer's Recommendations (attached). Units should also be cleaned immediately in the event of a spill.

Existing 24" Culvert and Outlet Control Structures

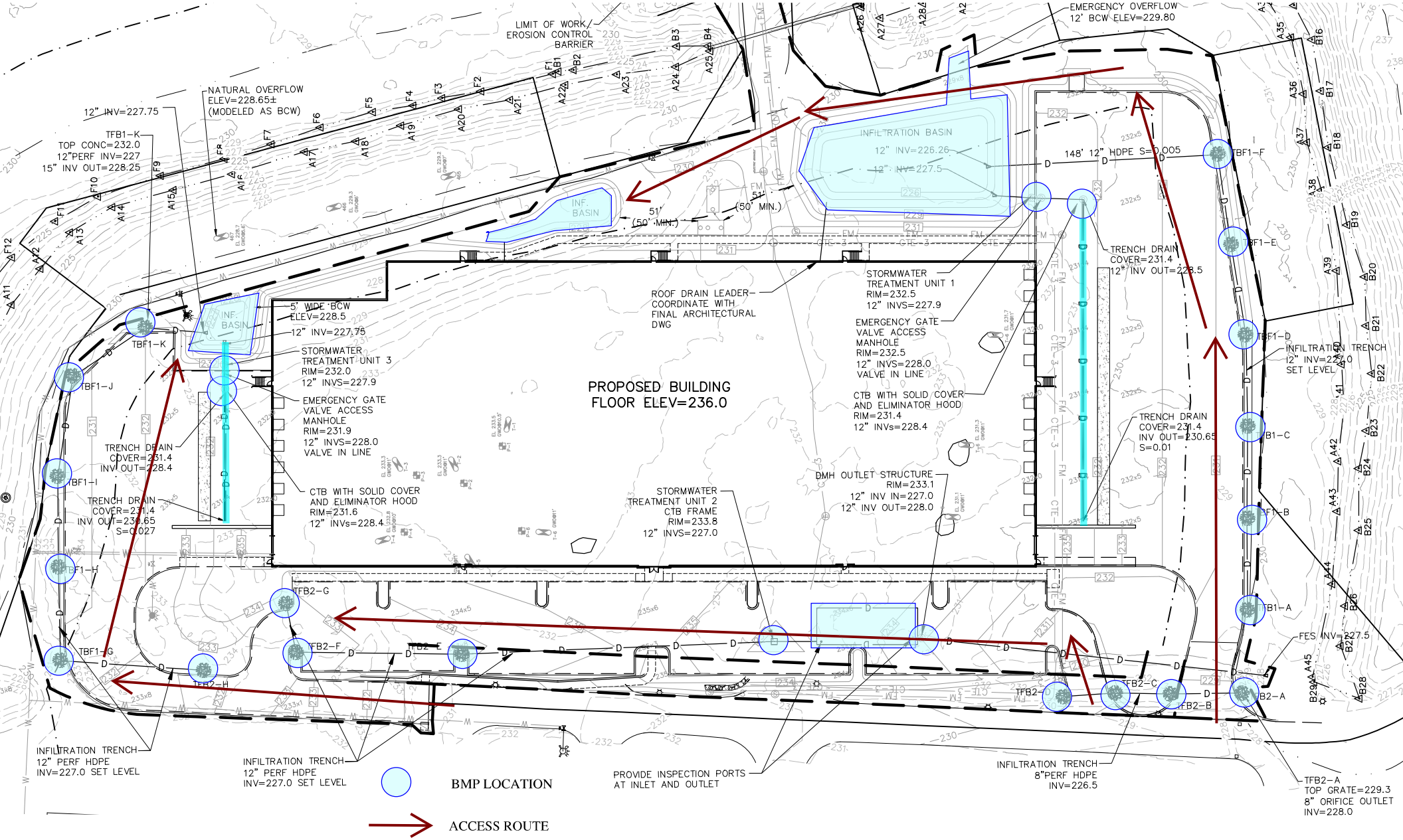
Inspect biannually. Inspect for structural soundness and confirm no blockage exists at openings, or within pipe; and no erosion is occurring at culvert or outlet control structure inlet or outlet. Remove trash, sediment, debris and vegetation. Restabilize area near inlets and outlets as necessary.

Infiltration Trenches

Inspect trenches every six months. Confirm inlet pipes are not blocked. Remove debris, as necessary.

Emergency Gate Valves

Emergency gate valves should be kept open. In case of a hazardous waste spill, close emergency gate valves to contain spill. Open and close emergency gate valves at least once yearly to confirm they are in good working condition.


LIMIT OF WORK/
EROSION CONTROL
BARRIER
NATURAL OVERFLOW
ELEV=228.65±
(MODELED AS BCW)
12" INV=227.75
TFB1-K
TOP CONC=232.0
12"PERF INV=227
15" INV OUT=228.25
INFILTRATION BASIN
12" INV=226.26
12" INV=227.5
INF. BASIN
51'
(50' MIN.)
EMERGENCY OVERFLOW
12' BCW ELEV=229.80
148' 12" HDPE S=0.005
TBF1-F
TBF1-E
TRENCH DRAIN
COVER=231.4
12" INV OUT=228.5
ROOF DRAIN LEADER-
COORDINATE WITH
FINAL ARCHITECTURAL
DWG
STORMWATER
TREATMENT UNIT 1
RIM=232.5
12" INVS=227.9
EMERGENCY GATE
VALVE ACCESS
MANHOLE
RIM=232.5
12" INVS=228.0
VALVE IN LINE
CTB WITH SOLID COVER
AND ELIMINATOR HOOD
RIM=231.4
12" INVs=228.4
5' WIDE BCW
ELEV=228.5
12" INV=227.75
STORMWATER
TREATMENT UNIT 3
RIM=232.0
12" INVS=227.9
EMERGENCY GATE
VALVE ACCESS
MANHOLE
RIM=231.9
12" INVS=228.0
VALVE IN LINE
CTB WITH SOLID COVER
AND ELIMINATOR HOOD
RIM=231.6
12" INVs=228.4
PROPOSED BUILDING
FLOOR ELEV=236.0
TBF1-K
TBF1-J
TBF1-I
TBF1-H
TBF1-G
TBF1-D
TBF1-B
TB1-C
TB1-A
TB2-A
TFB2-G
TFB2-F
TFB2-E
TFB2-H
TFB2
TFB2-C
TFB2-B
TRENCH DRAIN
COVER=231.4
INV OUT=228.4
TRENCH DRAIN
COVER=231.4
INV OUT=230.65
S=0.027
TRENCH DRAIN
COVER=231.4
INV OUT=230.65
S=0.01
INFILTRATION TRENCH
12" INV=227.0
SET LEVEL
DMH OUTLET STRUCTURE
RIM=233.1
12" INV IN=227.0
12" INV OUT=228.0
STORMWATER
TREATMENT UNIT 2
CTB FRAME
RIM=233.8
12" INVS=227.0
FES INV=227.5
INFILTRATION TRENCH
12" PERF HDPE
INV=227.0 SET LEVEL
INFILTRATION TRENCH
12" PERF HDPE
INV=227.0 SET LEVEL
PROVIDE INSPECTION PORTS
AT INLET AND OUTLET
INFILTRATION TRENCH
8"PERF HDPE
INV=226.5
TFB2-A
TOP GRATE=229.3
8" ORIFICE OUTLET
INV=228.0
BMP LOCATION
ACCESS ROUTE

Stormwater BMP Inspection and Maintenance Log

(print a log for each BMP and maintain a log book for the project)

BMP:_____

Date	Inspector	Issues Observed	Corrective Action Taken	Notes

CONTECH®
ENGINEERED SOLUTIONS

CDS® Inspection and Maintenance Guide

CDS TECHNOLOGIES

Maintenance

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

Inspection

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

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

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

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

Cleaning

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

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

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

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

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Support

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

©2017 Contech Engineered Solutions LLC, a QUIKRETE Company

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

NOTHING IN THIS CATALOG SHOULD BE CONSTRUED AS AN EXPRESSED WARRANTY OR AN IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SEE THE CONTECH STANDARD CONDITION OF SALES (VIEWABLE AT WWW.CONTECHES.COM/COS) FOR MORE INFORMATION.

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

CONTECH®
ENGINEERED SOLUTIONS
800.925.5240
www.ContechES.com

CDS Inspection & Maintenance Log

CDS Model: _____ Location: _____

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

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

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

Soils Data

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

A. Facility Information

CDK - MEL, LLC
Owner Name

MONARCH DRIVE
Street Address

R10 16 B
Map/Lot #

LITTLETON
City

MA
State

01460
Zip Code

B. Site Information

1. (Check one) ☒ New Construction ☒ Upgrade

2. Soil Survey NRCS (Source) 253D (Soil Map Unit) HINCKLEY, LOAMY SAND (Soil Series)
   OUTWASH (Landform) RAPID INFILTRATION (Soil Limitations)
   SANDY AND GRAVELLY GLACIOFLUVIAL DEPOSITS DERIVED FROM GNEISS, GRANITE, SCHIST (Soil Parent material)

3. Surficial Geological Report 2022 / Mass Mapper (Year Published/Source) GLACIAL STRATIFIED DEPOSITS (Map Unit)
   Gravel Stratified Deposits of well sorted to poorly sorted, gravel, sand, silt and clay in layers
   Description of Geologic Map Unit:

4. Flood Rate Insurance Map Within a regulatory floodway? ☐ Yes ☒ No

5. Within a velocity zone? ☐ Yes ☒ No

6. Within a Mapped Wetland Area? ☐ Yes ☒ No If yes, MassGIS Wetland Data Layer: (Wetland Type)

7. Current Water Resource Conditions (USGS): 3/4/22 (Month/Day/ Year) Range: ☐ Above Normal ☒ Normal ☐ Below Normal

8. Other references reviewed: (Zone II, IWPA, Zone A, EEA Data Portal, etc.) Mass GIS; Littleton GIS

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: DH-1 (Hole #) 3/4/22 (Date) 8:00 am (Time) 40° PtHy Cldy (Weather) 42°31'01" (Latitude) 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) — trees, scrub brush (Vegetation) — Few large boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.) — 2% (Slope (%))

Description of Location: wooded undeveloped area

2. Soil Parent Material: Glaciofluvial Deposits — Outwash Plain (Landform) — TS (Position on Landscape (SU, SH, BS, FS, TS, Plain))

3. Distances from: Open Water Body >750' feet — Drainage Way 100'± feet — Wetlands 90'± feet — Property Line 150'± feet — Drinking Water Well >200'± feet — Other _____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: N/A Depth to Weeping in Hole — 84" Depth to Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-4	Ap	FSL	10YR 3/2		Cnc : Dpl:					FRIABLE	
4-20	Bw	FSL	10YR 6/6		Cnc : Dpl:					FRIABLE	
20-120	C	FINE SAND	2.5Y 4/2	60"	Cnc : Dpl:				SINGLE GRAIN	LOOSE	
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes: -

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area*)

Deep Observation Hole Number: DH-2 (Hole #) | 3/4/22 (Date) | 8:15 am (Time) | 40° Pt Cldy (Weather) | 42°31'01" (Latitude) | 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | trees, scrub brush (Vegetation) | Few large boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 2% (Slope (%))

   Description of Location: wooded undeveloped area

2. Soil Parent Material: Glaciofluvial Deposits | Outwash Plain (Landform) | TS (Position on Landscape (SU, SH, BS, FS, TS, Plain))

3. Distances from: Open Water Body >750 feet | Drainage Way 150'± feet | Wetlands 135± feet | Property Line 200± feet | Drinking Water Well >200 feet | Other _____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: 105" Depth to Weeping in Hole | 84" Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-8	Ap	FSL	10YR 3/2		Cnc : Dpl:					FRIABLE	
8-26	Bw	FSL	10YR 5/6		Cnc : Dpl:					FRIABLE	
26-96	C	SAND	2.5Y 5/2	43"	Cnc : Dpl:		2%		SINGLE GRAIN	LOOSE	
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: DH-3 (Hole #) 3/4/22 (Date) 8:30 (Time) 40° Pt Ly Cldy (Weather) 42°31'01" (Latitude) 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) — trees, scrub brush (Vegetation) — Few large Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) — 2% (Slope (%))

Description of Location: wooded undeveloped area

2. Soil Parent Material: Glaciofluvial Deposits — Outwash Plain (Landform) — TS (Position on Landscape (SU, SH, BS, FS, TS, Plain))

3. Distances from: Open Water Body >200' feet — Drainage Way 190± feet — Wetlands 180± feet — Property Line 240± feet — Drinking Water Well >200 feet — Other _____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No — If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No — If yes: 96" Depth to Weeping in Hole — 82" Depth to Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-22	Ap	FSL	10YR 3/2		Cnc : Dpl:						
22-35	Bw	FSL	10YR 5/6		Cnc : Dpl:						
35-99	C	SAND	2.5Y 6/2	62	Cnc : Dpl:		2%		SINGLE GRAIN	LOOSE	
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area*)

Deep Observation Hole Number: DH-4 (Hole #) 3/4/22 (Date) 9:00am (Time) 40° PHy Cldy (Weather) 40°31'01" (Latitude) 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) trees, scrub brush (Vegetation) Few large Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.) 2% (Slope (%)

   Description of Location: wooded undeveloped land

2. Soil Parent Material: Glaciofluvial Deposits Landform: Outwash Plain Position on Landscape (SU, SH, BS, FS, TS, Plain): TS

3. Distances from: Open Water Body >75ft feet; Drainage Way 240± feet; Wetlands 140± feet; Property Line 220± feet; Drinking Water Well >200 feet; Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: — Depth to Weeping in Hole; 79" Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-3	O	FSL	10YR2/2		Cnc : Dpl:						
3-100	C	SAND	2.5Y5/2	52"	Cnc : Dpl:			2%	SINGLE GRAIN	LOOSE	
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: DH-5 (Hole #) | 3/4/22 (Date) | 9:15 (Time) | 40° Ply Cldy (Weather) | 42°31'01" (Latitude) | 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | trees, scrub brush (Vegetation) | Few large boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 2% (Slope (%))

Description of Location: undeveloped wooded area

2. Soil Parent Material: Glaciofluvial Deposits | Outwash Plain (Landform) | TS (Position on Landscape (SU, SH, BS, FS, TS, Plain))

3. Distances from: Open Water Body >800 feet | Drainage Way 165± feet | Wetlands 140± feet | Property Line 215± feet | Drinking Water Well >200 feet | Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: — Depth to Weeping in Hole | 81" Depth to Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-6	Ap	FSL	10YR 3/2		Cnc : Dpl:						
6-18	Bw	FSL	10YR 5/6		Cnc : Dpl:						
18-98	C	SAND	2.5Y 6/2	42"	Cnc : Dpl:				SINGLE GRAIN	LOOSE	
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area*)

Deep Observation Hole Number: DH-6 (Hole #) | 3/4/22 (Date) | 9:30 (Time) | 40° Pt Cldy (Weather) | 42°31'01" (Latitude) | 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | trees, scrub brush (Vegetation) | Few large Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 2% (Slope (%))

   Description of Location: wooded, undeveloped area

2. Soil Parent Material: Glaciofluvial Deposits | Outwash Plain (Landform) | B (Position on Landscape (SU, SH, BS, FS, TS, Plain))

3. Distances from: Open Water Body >800 feet | Drainage Way 145± feet | Wetlands 115± feet | Property Line 175± feet | Drinking Water Well >200 feet | Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: ____ Depth to Weeping in Hole | 82" Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-8	Ap	FSL	10YR 2/2		Cnc : Dpl:						
8-36	Bw	FSL	10YR 5/6		Cnc : Dpl:						
36-122	C	SAND	2.5Y 6/2	84"	Cnc : Dpl:				SINGLE GRAIN	LOOSE	
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (*minimum of two holes required at every proposed primary and reserve disposal area*)

Deep Observation Hole Number: DH-7 (Hole #) | 3/4/22 (Date) | 9:45 (Time) | 40° PtCldy (Weather) | 42°31.01' (Latitude) | 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | trees, scrub brush (Vegetation) | Few large boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.) | 2 (Slope (%))

Description of Location: wooded undeveloped area

2. Soil Parent Material: Glaciofluvial Deposits | Outwash Plain (Landform) | TS (Position on Landscape (SU, SH, BS, FS, TS, Plain))

3. Distances from: Open Water Body >300 feet | Drainage Way 130± feet | Wetlands 90 feet | Property Line 200± feet | Drinking Water Well >200 feet | Other ____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: 96" Depth to Weeping in Hole | 76" Depth to Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-3	O		10YR 3/2		Cnc : Dpl:						
3-98	C		2.5Y 4/2	10"	Cnc : Dpl:				SINGLE GRAIN	LOOSE	
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: DH-8 (Hole #) | 3/4/22 (Date) | 10:15 (Time) | 45° Pt Cldy (Weather) | 42°31'01" (Latitude) | 71°30'57" (Longitude)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) | trees, scrub brush (Vegetation) | Few large boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) | 2% (Slope (%))

   Description of Location: wooded undeveloped area

2. Soil Parent Material: Glaciofluvial Deposits | Outwash Plain (Landform) | TS (Position on Landscape (SU, SH, BS, FS, TS, Plain))

3. Distances from: Open Water Body >350± feet | Drainage Way 120± feet | Wetlands 103± feet | Property Line 205± feet | Drinking Water Well >200 feet | Other _____ feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil/Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: 52" Depth to Weeping in Hole | 68" Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-4	O		10YR 2/2		Cnc : Dpl:						
4-90	C	FINE SAND	2.5Y 4/1	28"	Cnc : Dpl:					SINGLE GRAIN	LOOSE
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						
					Cnc : Dpl:						

Additional Notes:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method Used (Choose one):

	Obs. Hole # DH-1	Obs. Hole # DH-2	DH-3	DH-4
☒ Depth to soil redoximorphic features	60 inches	43 inches	62"	52"
☐ Depth to observed standing water in observation hole	_____ inches	_____ inches		
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	_____ inches		

_____ Index Well Number _____ Reading Date

$S_h = S_c - [S_r \times (OW_c - OW_{max})/OW_r]$

Obs. Hole/Well# _____ S_c _____ S_r _____ OW_c _____ OW_{max} _____ OW_r _____ S_h _____

E. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

Patrick Burke II — Signature of Soil Evaluator

4/8/22 — Date

Patrick J. Burke II / SE2278 — Typed or Printed Name of Soil Evaluator / License #

6/30/22 — Expiration Date of License

James Garreffi — Name of Approving Authority Witness

NABOH — Approving Authority

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method Used (Choose one):

	Obs. Hole # DH-5	Obs. Hole # DH-6	DH-7	DH-8
☒ Depth to soil redoximorphic features	42" inches	84" inches	10"	28"
☐ Depth to observed standing water in observation hole	_____ inches	_____ inches		
☐ Depth to adjusted seasonal high groundwater (S_h) (USGS methodology)	_____ inches	_____ inches		

Index Well Number _____ Reading Date _____

$S_h = S_c - [S_r \times (OW_c - OW_{max})/OW_r]$

Obs. Hole/Well# _____ S_c _____ S_r _____ OW_c _____ OW_{max} _____ OW_r _____ S_h _____

E. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

Patrick J Burke II — Signature of Soil Evaluator

4/8/22 — Date

Patrick J Burke II / SE2778 — Typed or Printed Name of Soil Evaluator / License #

6/30/22 — Expiration Date of License

James Garreffi — Name of Approving Authority Witness

NABoH — Approving Authority

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Commonwealth of Massachusetts
City/Town of
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

CDK-MEL, LLC
Owner Name

MONARCH DRIVE
Street Address or Lot #

LITTLETON | MA | 01460
City/Town | State | Zip Code

Contact Person (if different from Owner) | Telephone Number

B. Test Results

	3/4/22 Date	12:56 Time	3/4/22 Date	11:29 Time
Observation Hole #	PT-1		PT-2	
Depth of Perc	33" shelf		34" Shelf	
Start Pre-Soak	12:56 pm		1:21 pm	
End Pre-Soak	1:14 pm		1:36 pm	
Time at 12"	1:14 pm		1:36 pm	
Time at 9"	1:15 pm		1:42 pm	
Time at 6"	1:17 pm		1:47 pm	
Time (9"-6")	2 min		5 min	
Rate (Min./Inch)	< 2 min/inch		< 2 min/inch	
	Test Passed: ☒ Test Failed: ☐		Test Passed: ☒ Test Failed: ☐	

Patrick J. Burke SIZ 2~~3~~4
Test Performed By:

James Garreffi NABOH
Board of Health Witness

Comments:

PT-1 tested next to DH-1

PT-2 tested next to DH-3

Commonwealth of Massachusetts
City/Town of
Percolation Test
Form 12

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

CDK - MEC, LLC
Owner Name

MONARCH DRIVE
Street Address or Lot #

LITTLETON | MA | 01460
City/Town | State | Zip Code

Contact Person (if different from Owner) | Telephone Number

B. Test Results

	Date	Time	Date	Time
	3/4/22		3/4/22	
Observation Hole #	PT-3		PT-4	
Depth of Perc	24" Shelf		30" Shelf	
Start Pre-Soak	12:29 pm		12:42	
End Pre-Soak	12:44 pm		12:57	
Time at 12"	12:44 pm		24 gallons	
Time at 9"	1:30 pm		poured	
Time at 6"	2:19 pm			
Time (9"-6")	49 MIN			
Rate (Min./Inch)	17 MIN/INCH			
	Test Passed: ☒ Test Failed: ☐		Test Passed: ☒ Test Failed: ☐	

Patrick J. Burke Sr 278
Test Performed By:

James Garreffi
Board of Health Witness

Comments:

PT-3 tested next to DH-7

PT-4 tested next to DH-6

PLACES
Associates, Inc.
Planning
Landscape Architecture
Civil Engineering
Surveying

SOILS OBSERVATION AND TESTING REPORT

Site Location: Monarch Drive, Littleton, MA
Project No.: 5554
Date: 03/04/2022
Time of Testing: 2:00 PM

Weather No precipitation
Temp: 45^{o} F
Sky Condition: Partly Cloudy

Notes:

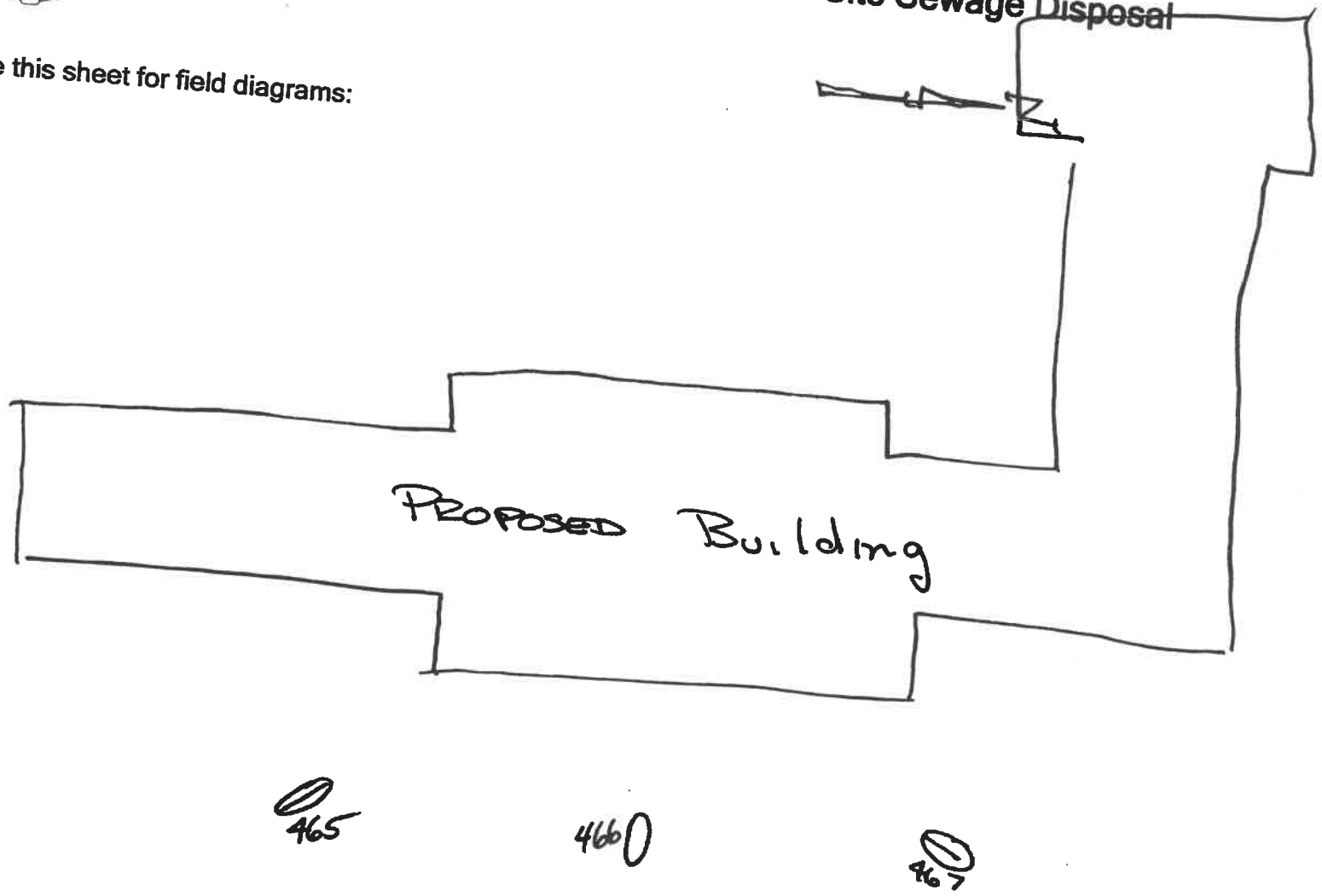
SW #1:	0”-1”	Organic
	1”–96”	Sand, single grain loose
		No groundwater observed
		No Redox observed
SW #2:	0”-2”	Organic
	1”–78”	Sand, single grain loose
		No groundwater observed
		Redox @72”
SW #3:	0”-2”	Organic
	1”–96”	Sand, single grain loose
		No groundwater observed
		Redox @58”
SW #4:	0”-3”	Organic
	3”–140”	Sand, single grain loose
		Groundwater observed weeping@140”
		No Redox observed

Plot

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Use this sheet for field diagrams:



Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

MONARCH DRIVE COPY

JOB FILE LIT-0007

DEP has provided this form for use by on-site professionals and local Boards of Health. Other forms may be used, but the information must be substantially the same as provided here. Before using this form, check with your local Board of Health to determine the form they use.

A. Facility Information

1. Facility Information

Owner Name: WATERFORD DEVELOPMENT

Street Address: 175 HIGHLAND AVE Map/Lot:

City/Town: NEEDHAM State: MA Zip Code: 02494

HAYES ENGINEERING, INC.
603 SALEM ST
WAKEFIELD, MA 01880
TEL.: [illegible] 2800
FAX: [illegible] 6-7596

T-1 + T-2

B. Site Information

1. (Check one) New Construction ☑ Upgrade ☐ Repair ☐

2. Published Soil Survey available? Yes ☐ No ☐ If yes: Year Published Publication Scale Soil Map Unit

Soil Name Soil limitations

3. Surficial Geological Report available? Yes ☐ No ☐ If yes: Year Published Publication Scale Map Unit

Geologic Material Landform

4. Flood Rate Insurance Map:

Above the 500 year flood boundary? Yes ☐ No ☐

Within the 500 year flood boundary? Yes ☐ No ☐

Within the 100 year flood boundary? Yes ☐ No ☐

Within a Velocity Zone? Yes ☐ No ☐

5. Wetland Area: National Wetland Inventory Map Map Unit Name

Wetlands Conservancy Program Map Map Unit Name

6. Current Water Resource Conditions (USGS) Month/Year Range: Above Normal ☐ Normal ☐ Below Normal ☐

7. Other references reviewed:

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method used:		T-1	T-2
☐	Depth observed standing water in observation hole	A. 126 inches	B. 132 inches
☐	Depth weeping from side of observation hole	A. 126 inches	B. 132 inches
☐	Depth to soil redoximorphic features (mottles)	A. 126 inches	B. 132 inches
☐	Groundwater adjustment (USGS methodology)	A. _____ inches	B. _____ inches

2. Index Well Number _____ Reading Date _____ Index Well Level _____

Adjustment Factor _____ Adjusted Groundwater Level _____

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

   a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes ☐ No ☐

   b. If yes, at what depth was it observed? Upper boundary: _____ inches Lower boundary: _____ inches

F. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

Signature of Soil Evaluator — Date: April 8, 2008

Gordon Rogerson SE 2074
Typed or Printed Name of Soil Evaluator/License Number — *Date of Soil Evaluator Exam: Nov. 1994

Jim Garreffi Dave Boyer (DEP)
Name of Board of Health Witness — Board of Health: LITTLETON

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: T-1 4-8-08 ____ Sunny 50°
Date Time Weather

1. Location

Ground Elevation at Surface of Hole ____

Location (Identify on Plan) ____

2. Land Use: FIELD (e.g. woodland, agricultural field, vacant lot, etc.) ____ ND ____ A
Vegetation: Grasses ____ Landform ____ Surface Stones ____ Slope (%) ____ Position on landscape (attach sheet)

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Possible Wet Area ____ feet
Property Line ____ feet Drinking Water Well ____ feet Other ____

4. Parent Material: Glacial Outwash

If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Unsuitable Materials Present: Yes ☐ No ☑
Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

If Yes: Depth Weeping from Pit 126 Depth Standing Water in Hole 126

Estimated Depth to High Groundwater: 126 inches ____ elevation

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: T-1

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0 - 12	Bw	10YR 5/6				ls	0	0%	m	mvfr	
12 - 132	C	2.5Y 6/3	126			cs	30	0%	sg	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: T-2 4-8-08 (Date) ____ (Time) Sunny 50° (Weather)

1. Location

Ground Elevation at Surface of Hole ____

Location (Identify on Plan) ____

2. Land Use: FIELD (e.g. woodland, agricultural field, vacant lot, etc.) NO (Surface Stones) A (Slope (%))

Vegetation: grasses Landform: ____ Position on landscape (attach sheet): ____

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Possible Wet Area ____ feet

Property Line ____ feet Drinking Water Well ____ feet Other ____

4. Parent Material: Glacial Outwash

If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Unsuitable Materials Present: Yes ☐ No ☑

Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

If Yes: Depth Weeping from Pit 132 Depth Standing Water in Hole 132

Estimated Depth to High Groundwater: 132 inches ____ elevation

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: T-2

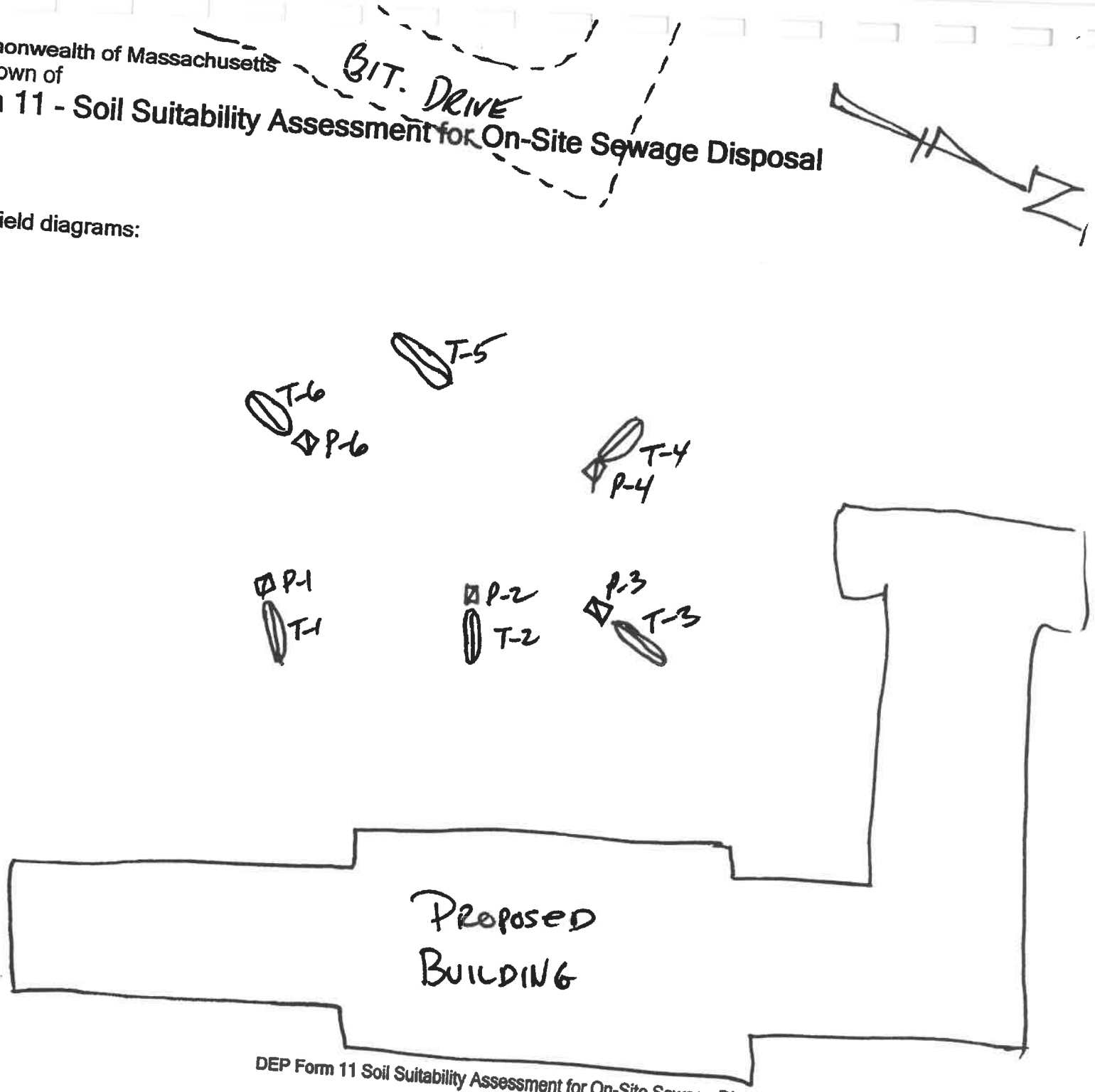
Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0 – 10	Bw	10YR 5/6				ls	0	0/0	m	mvfr	
10 – 96	C1	2.5Y 6/4				m/c s	0	0/0	sg	mvfr	
96 – 144	C2	2.5Y 6/3	132			cs	30	0/0	sg	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Use this sheet for field diagrams:



Commonwealth of Massachusetts
City/Town of LITTLETON
Percolation Test
Form 12

HAYES ENG[illegible], INC.
603 SALE[illegible]
WAKEF[illegible] MA 01880
T[illegible] (781) 246-2800
[illegible] (781) 246-7596

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name: Waterford Development
Street Address or Lot #: 175 HIGHLAND AVE
City/Town: NEEDHAM
State: MA
Zip Code:
Contact Person (if different from Owner):
Telephone Number:

B. Test Results

Observation Hole #	P-1	P-2
Date	4-8-08	4-8-08
Time		
Depth of Perc	18" + 18" = 36"	21" + 18" = 39"
Start Pre-Soak	9:14	9:18
End Pre-Soak	25gals	25gals
Time at 12"	9:16	9:29
Time at 9"		
Time at 6"	9:17	9:32
Time (9"-6")	1	3
Rate (Min./Inch)	<2m/1	<2m/1
Test Passed:	☑	☑
Test Failed:	☐	☐

Test Performed By: Gordon Rogerson
Witnessed By: Dave Boyer (DEP)
Comments:

t5form12.doc• 06/03

Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

MONARCH DRIVE

JOB FILE LIT-0007

DEP has provided this form for use by on-site professionals and local Boards of Health. Other forms may be used, but the information must be substantially the same as provided here. Before using this form, check with your local Board of Health to determine the form they use.

A. Facility Information

1. Facility Information

Owner Name: WATERFORD DEVELOPMENT

Street Address: 175 HIGHLAND AVE

City/Town: NEEDHAM State: MA Zip Code: 02494 Map/Lot:

HAYES ENGINEERING, INC.
603 SALEM ST
WAKEFIELD, MA 01880
TEL.: [illegible] 2800
FAX: [illegible] 6-7596

T-3 + T-4

B. Site Information

1. (Check one) New Construction ☐ Upgrade ☐ Repair ☐

2. Published Soil Survey available? Yes ☐ No ☐ If yes: Year Published ____ Publication Scale ____ Soil Map Unit ____

Soil Name ____ Soil limitations ____

3. Surficial Geological Report available? Yes ☐ No ☐ If yes: Year Published ____ Publication Scale ____ Map Unit ____

Geologic Material ____ Landform ____

4. Flood Rate Insurance Map:

Above the 500 year flood boundary? Yes ☐ No ☐ Within the 100 year flood boundary? Yes ☐ No ☐

Within the 500 year flood boundary? Yes ☐ No ☐ Within a Velocity Zone? Yes ☐ No ☐

5. Wetland Area: National Wetland Inventory Map Map Unit ____ Name ____

Wetlands Conservancy Program Map Map Unit ____ Name ____

6. Current Water Resource Conditions (USGS) Month/Year ____ Range: Above Normal ☐ Normal ☐ Below Normal ☐

7. Other references reviewed: ____

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method used:		T-3	T-4
☐	Depth observed standing water in observation hole	A. 132 inches	B. 120 inches
☐	Depth weeping from side of observation hole	A. 132 inches	B. 120 inches
☐	Depth to soil redoximorphic features (mottles)	A. 132 inches	B. 120 inches
☐	Groundwater adjustment (USGS methodology)	A. _____ inches	B. _____ inches

2. Index Well Number _____ Reading Date _____ Index Well Level _____

Adjustment Factor _____ Adjusted Groundwater Level _____

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes ☐ No ☐

b. If yes, at what depth was it observed? Upper boundary: _____ inches Lower boundary: _____ inches

F. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

Signature of Soil Evaluator — Date: April 8 2008

Gordon Rogerson SE 2074
Typed or Printed Name of Soil Evaluator/License Number — Date of Soil Evaluator Exam: Nov. 1994

Jim Garreffi Dave Boyer (DEP)
Name of Board of Health Witness

L. Hilton
Board of Health

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: T-3 4-8-08 (Date) ____ (Time) Sunny 50° (Weather)

1. Location

   Ground Elevation at Surface of Hole ____

   Location (Identify on Plan) ____

2. Land Use: FIELD (e.g. woodland, agricultural field, vacant lot, etc.) NO (Surface Stones) A (Slope (%))

   grasses (Vegetation) ____ (Landform) ____ (Position on landscape (attach sheet))

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Possible Wet Area ____ feet

   Property Line ____ feet Drinking Water Well ____ feet Other ____

4. Parent Material: Glacial Outwash Unsuitable Materials Present: Yes ☐ No ☑

   If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

   If Yes: Depth Weeping from Pit 132 Depth Standing Water in Hole 132

   Estimated Depth to High Groundwater: 132 inches ____ elevation

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: T-3

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-12	Bw	10YR 5/6				fs	0	0/0	m	mvfr	
12-104	C1	2.5Y 6/4				f/m S	0	0/0	m	mvfr	
104-140	C2	2.5Y 6/3	132			cs	20	0/0	sg	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: ____ T-4

1. Location

Date: ____ Time: ____ Weather: Sunny 50°

Ground Elevation at Surface of Hole ____

Location (Identify on Plan) ____

2. Land Use: FIELD (e.g. woodland, agricultural field, vacant lot, etc.)

Vegetation: grasses Surface Stones: No Slope (%): A

Landform ____ Position on landscape (attach sheet) ____

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Possible Wet Area ____ feet

Property Line ____ feet Drinking Water Well ____ feet Other ____

4. Parent Material: Glacial Outwash

If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Unsuitable Materials Present: Yes ☐ No ☑

Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

If Yes: Depth Weeping from Pit 120 Depth Standing Water in Hole 120

Estimated Depth to High Groundwater: 120 inches ____ elevation

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: T-4

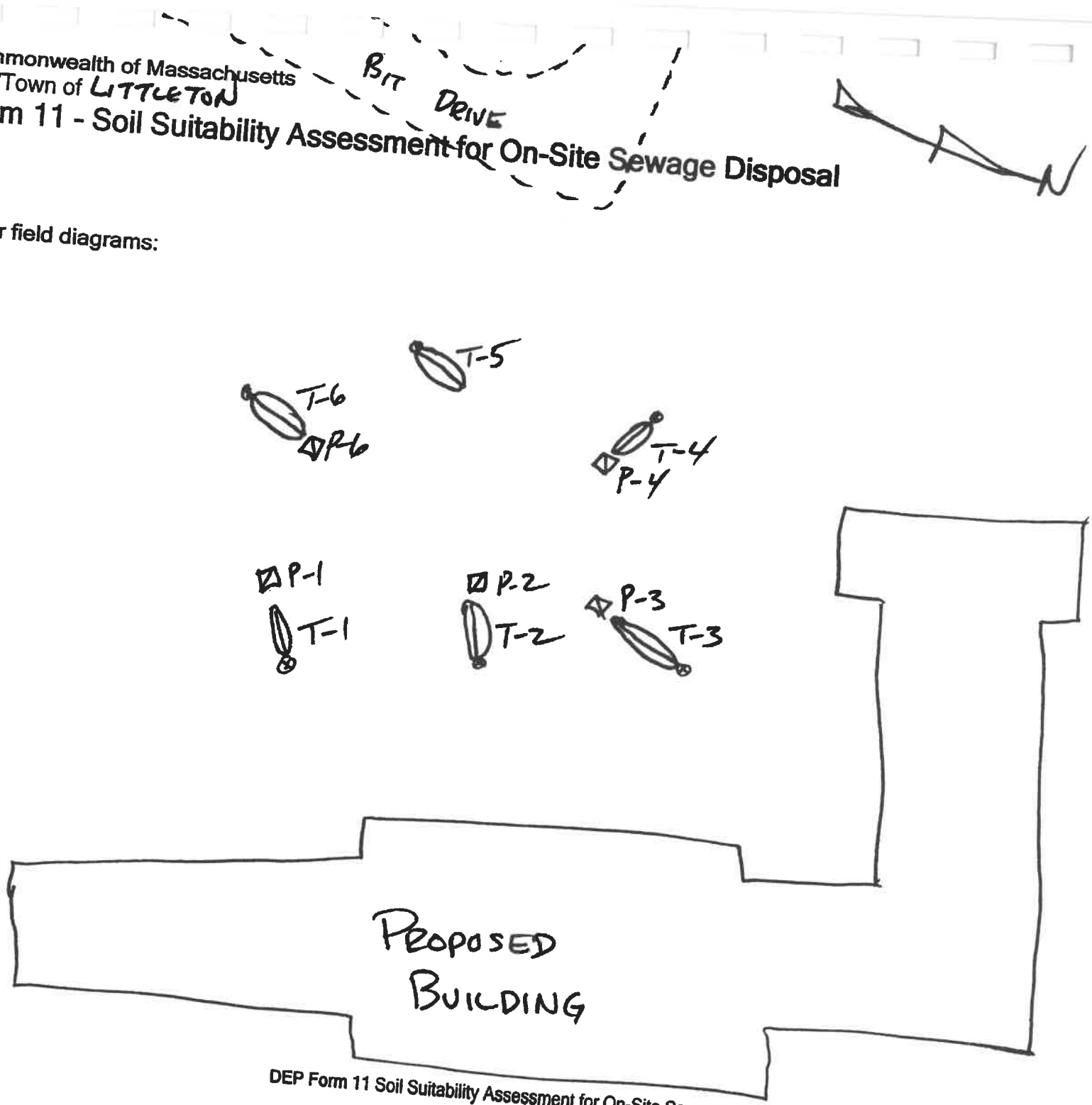
Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-13	Bw	10YR 5/6				ls	0	0/0	m	mvfr	
13-126	C	2.5Y 6/4	120			m/c s	0	0/0	sg	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Use this sheet for field diagrams:



Commonwealth of Massachusetts
City/Town of LITTLETON
Percolation Test
Form 12

HAYES ENG... INC.
603 SALE... ET
WAKEF... MA 01880
T... (781) 246-2800
F... (781) 246-7596

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name: Waterford Development
Street Address or Lot #: 179 HIGHLAND
City/Town: NEEDHAM State: MA Zip Code:
Contact Person (if different from Owner): Telephone Number:

B. Test Results

Observation Hole #	P-3	P-4
Date	4-8-08	4-8-08
Time		
Depth of Perc	30"+18"=48"	28"+18"=46"
Start Pre-Soak	9:37	9:57
End Pre-Soak	25gals	25gals
Time at 12"	9:49	10:08
Time at 9"	9:51	10:09
Time at 6"	9:56	10:11
Time (9"-6")	5	2
Rate (Min./Inch)	<2m/1	<2m/1
Test Passed: ☑ / Test Failed: ☐	☑	☑

Test Performed By: Gordon Rogerson
Witnessed By: DAVE BOYER (DEP)

Comments:
MONARCH DRIVE

City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

MONARCH DRIVE

JOB FILE LIT-0007

DEP has provided this form for use by on-site professionals and local Boards of Health. Other forms may be used, but the information must be substantially the same as provided here. Before using this form, check with your local Board of Health to determine the form they use.

A. Facility Information

1. Facility Information

Owner Name: WATERFORD DEVELOPMENT

Street Address: 175 HIGHLAND AVE. Map/Lot:

City/Town: NEEDHAM State: MA. Zip Code: 02494

HAYES ENGINEERING, INC.
603 SALEM ST
WAKEFIELD, MA 01880
TEL.: [illegible] 2800
FAX: [illegible] 6-7596

T-5 + T-6

B. Site Information

1. (Check one) New Construction ☑ Upgrade ☐ Repair ☐

2. Published Soil Survey available? Yes ☐ No ☐ If yes:

Soil Name | Year Published | Publication Scale | Soil Map Unit

Soil limitations

3. Surficial Geological Report available? Yes ☐ No ☐ If yes:

Geologic Material | Year Published | Publication Scale | Map Unit

Landform

4. Flood Rate Insurance Map:

Above the 500 year flood boundary? Yes ☐ No ☐

Within the 500 year flood boundary? Yes ☐ No ☐

Within the 100 year flood boundary? Yes ☐ No ☐

Within a Velocity Zone? Yes ☐ No ☐

5. Wetland Area: National Wetland Inventory Map Map Unit

Wetlands Conservancy Program Map Map Unit

Name

Name

6. Current Water Resource Conditions (USGS) Month/Year Range: Above Normal ☐ Normal ☐ Below Normal ☐

7. Other references reviewed:

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method used:		T-5	T-6
☐	Depth observed standing water in observation hole	A. 132 inches	B. 132 inches
☐	Depth weeping from side of observation hole	A. 132 inches	B. 132 inches
☐	Depth to soil redoximorphic features (mottles)	A. 132 inches	B. 132 inches
☐	Groundwater adjustment (USGS methodology)	A. _____ inches	B. _____ inches

2. Index Well Number _____ Reading Date _____ Index Well Level _____

Adjustment Factor _____ Adjusted Groundwater Level _____

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

   a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes ☐ No ☐

   b. If yes, at what depth was it observed? Upper boundary: _____ inches Lower boundary: _____ inches

F. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

Signature of Soil Evaluator — Date: April 8, 2008

Gordon Rogerson SE 2074
Typed or Printed Name of Soil Evaluator/License Number — *Date of Soil Evaluator Exam: NOV. 1994

Jim Garreffi Dave Boyer (DGD)
Name of Board of Health Witness — Board of Health: LITTLETON

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: T-5 4-8-08 (Date) _____ (Time) Sunny 50° (Weather)

1. Location

Ground Elevation at Surface of Hole _____

Location (Identify on Plan) _____

2. Land Use: FIELD (e.g. woodland, agricultural field, vacant lot, etc.) NO (Surface Stones) A (Slope (%))

Grasses (Vegetation) _____ (Landform) _____ (Position on landscape (attach sheet))

3. Distances from: Open Water Body _____ feet Drainage Way _____ feet Possible Wet Area _____ feet

Property Line _____ feet Drinking Water Well _____ feet Other _____

4. Parent Material: Glacial Outwash Unsuitable Materials Present: Yes ☐ No ☒

If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☒ No ☐

If Yes: Depth Weeping from Pit 132 Depth Standing Water in Hole 132

Estimated Depth to High Groundwater: 132 inches _____ elevation

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: T-5

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-9	Bw	10YR 5/6				ls	0	0%	m	mvfr	
9-144	C	2.5Y 6/4	132			m/c s	0	0%	sg	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: T-6 4-8-08 (Date) ____ (Time) Sonny 50° (Weather)

1. Location

   Ground Elevation at Surface of Hole ____

   Location (Identify on Plan) ____

2. Land Use: Field (e.g. woodland, agricultural field, vacant lot, etc.) No (Surface Stones) A (Slope (%))

   Vegetation grasses (Landform) ____ (Position on landscape (attach sheet)) ____

3. Distances from: Open Water Body ____ feet Drainage Way ____ feet Possible Wet Area ____ feet

   Property Line ____ feet Drinking Water Well ____ feet Other ____

4. Parent Material: Glacial Outwash

   If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Unsuitable Materials Present: Yes ☐ No ☑

   Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

   If Yes: Depth Weeping from Pit 132 Depth Standing Water in Hole 132

   Estimated Depth to High Groundwater: 132 inches ____ elevation

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: T-6

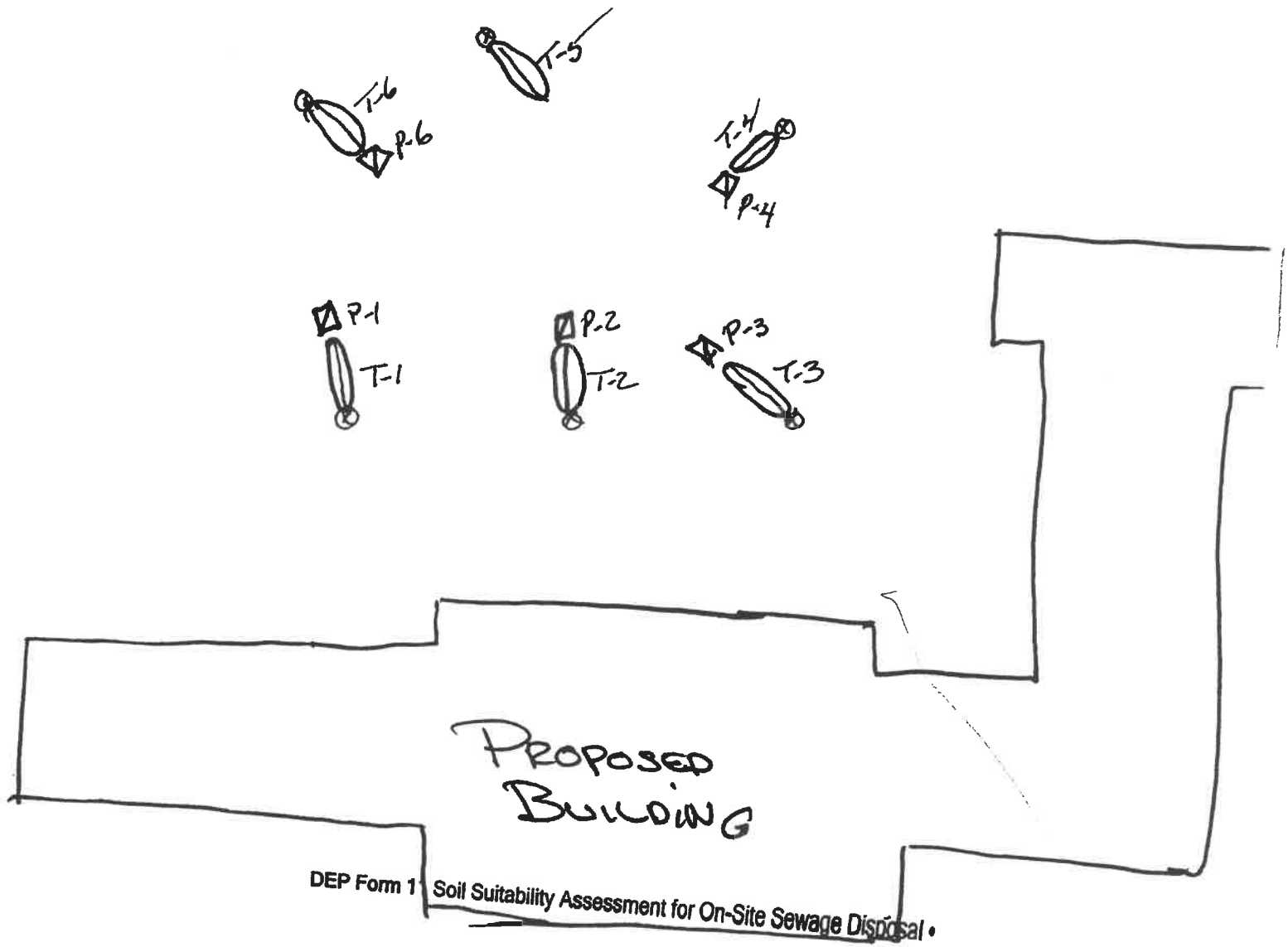
Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-6	Bw	10YR 5/6				ls	0	0/0	m	mvfr	
6-156	C	2.5Y 6/4	132			m/c s	30	0/0	sg	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Use this sheet for field diagrams:



Commonwealth of Massachusetts
City/Town of LITTLETON
Percolation Test
Form 12

HAYES ENG... INC.
603 SALEM ... STREET
WAKEF... MA 01880
T... (781) 246-2800
(781) 246-7596

Percolation test results must be submitted with the Soil Suitability Assessment for On-site Sewage Disposal. DEP has provided this form for use by local Boards of Health. Other forms may be used, but the information must be substantially the same as that provided here. Before using this form, check with the local Board of Health to determine the form they use.

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

A. Site Information

Owner Name: WATERFORD DEVELOPMENT

Street Address or Lot #: 179 HIGHLAND AVE

City/Town: NEEDHAM State: MA Zip Code:

Contact Person (if different from Owner): Telephone Number:

B. Test Results

	Date	Time	Date	Time
Observation Hole #			4-8-08	
Depth of Perc			P-6	
Start Pre-Soak			22"+18" = 40"	
End Pre-Soak			10:06	
Time at 12"			25gals	
Time at 9"			10:08	
Time at 6"			10:09	
Time (9"-6")			10:10	
Rate (Min./Inch)			1	
			<2m/1	
	Test Passed: ☐ Test Failed: ☐		Test Passed: ☑ Test Failed: ☐	

Test Performed By: Gordon Rogerson

Witnessed By: Dave BOYER (DEP)

Comments:

MONARCH DRIVE

City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

JOB FILE LIT-0007

DEP has provided this form for use by on-site professionals and local Boards of Health. Other forms may be used, but the information must be substantially the same as provided here. Before using this form, check with your local Board of Health to determine the form they use.

A. Facility Information

1. Facility Information

Owner Name: WATERFORD DEVELOPMENT

Street Address: MONARCH DRIVE

City/Town: LITTLETON State: MA Zip Code: Map/Lot:

HAYES ENGINEERING, INC.
603 SALEM ST
WAKEFIELD, MA 01880
TEL.: (781) 914-2800
FAX: (781) 246-7596

B. Site Information

1. (Check one) New Construction ☑ Upgrade ☐ Repair ☐

2. Published Soil Survey available? Yes ☐ No ☐ If yes: Year Published Publication Scale Soil Map Unit

Soil Name Soil limitations

3. Surficial Geological Report available? Yes ☐ No ☐ If yes: Year Published Publication Scale Map Unit

Geologic Material Landform

4. Flood Rate Insurance Map:

Above the 500 year flood boundary? Yes ☐ No ☐

Within the 500 year flood boundary? Yes ☐ No ☐

Within the 100 year flood boundary? Yes ☐ No ☐

Within a Velocity Zone? Yes ☐ No ☐

5. Wetland Area: National Wetland Inventory Map Map Unit Name

Wetlands Conservancy Program Map Map Unit Name

6. Current Water Resource Conditions (USGS) Month/Year Range: Above Normal ☐ Normal ☐ Below Normal ☐

7. Other references reviewed:

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

D. Determination of High Groundwater Elevation

1. Method used:

	A.	B.	A.	B.
☐ Depth observed standing water in observation hole	_____ inches	_____ inches	_____ inches	_____ inches
☐ Depth weeping from side of observation hole	_____ inches	_____ inches	_____ inches	_____ inches
☐ Depth to soil redoximorphic features (mottles)	_____ inches	_____ inches	_____ inches	_____ inches
☐ Groundwater adjustment (USGS methodology)	_____ inches	_____ inches	_____ inches	_____ inches

2. Index Well Number _____ Reading Date _____ Index Well Level _____

Adjustment Factor _____ Adjusted Groundwater Level _____

E. Depth of Pervious Material

1. Depth of Naturally Occurring Pervious Material

   a. Does at least four feet of naturally occurring pervious material exist in all areas observed throughout the area proposed for the soil absorption system? Yes ☐ No ☐

   b. If yes, at what depth was it observed? Upper boundary: _____ inches Lower boundary: _____ inches

F. Certification

I certify that I am currently approved by the Department of Environmental Protection pursuant to 310 CMR 15.017 to conduct soil evaluations and that the above analysis has been performed by me consistent with the required training, expertise and experience described in 310 CMR 15.017. I further certify that the results of my soil evaluation, as indicated in the attached Soil Evaluation Form, are accurate and in accordance with 310 CMR 15.100 through 15.107.

Signature of Soil Evaluator

Gordon Rogerson SE 2074
Typed or Printed Name of Soil Evaluator/License Number

Date Nov. 1994
*Date of Soil Evaluator Exam

Name of Board of Health Witness

Board of Health

Note: In accordance with 310 CMR 15.018(2) this form must be submitted to the approving authority within 60 days of the date of field testing, and to the designer and the property owner with Percolation Test Form 12.

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: 465 4-9-08 _____ Sunny 50°
Date Time Weather

1. Location

Ground Elevation at Surface of Hole _____

Location (Identify on Plan) _____

2. Land Use: FIELD
(e.g. woodland, agricultural field, vacant lot, etc.)

grasses (Vegetation) _____ (Landform) NO (Surface Stones) A (Slope (%)) _____ (Position on landscape (attach sheet))

3. Distances from: Open Water Body _____ feet Drainage Way _____ feet Possible Wet Area 40± feet

Property Line _____ feet Drinking Water Well _____ feet Other _____

4. Parent Material: Glacial Outwash

If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Unsuitable Materials Present: Yes ☐ No ☑

Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

If Yes: Depth Weeping from Pit 84 Depth Standing Water in Hole 84

Estimated Depth to High Groundwater: 84 inches _____ elevation

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: 465

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-32	C_1	10YR 5/6				gr CS	45	0%	5g	mvfr	
32-108	C_2	2.5Y 6/3	84			CS	20	0%	5g	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: 466 4-8-08 _____ Sunny 50°

Date _____ Time _____ Weather

1. Location

   Ground Elevation at Surface of Hole _____

   Location (Identify on Plan) _____

2. Land Use: FIELD
   (e.g. woodland, agricultural field, vacant lot, etc.)

   Vegetation: grasses _____ Surface Stones: NO _____ Slope (%): A

   Landform _____ Position on landscape (attach sheet) _____

3. Distances from: Open Water Body _____ feet Drainage Way _____ feet Possible Wet Area _____ feet

   Property Line _____ feet Drinking Water Well _____ feet Other _____

4. Parent Material: Glacial Outwash

   If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Unsuitable Materials Present: Yes ☐ No ☑

   Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

   If Yes: Depth Weeping from Pit 72 Depth Standing Water in Hole 72

   Estimated Depth to High Groundwater: 72 inches _____ elevation

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: 466

Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-30	C1	10YR 5/6				grCS	45	0%	3g	mvfr	
30-96	C2	2.5Y 6/3	72			CS	35	0%	3g	mvfr	

Additional Notes _____

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (Cont.)

Deep Observation Hole Number: 467 4-8-08 (Date) _____ (Time) Sunny 50° (Weather)

1. Location

Ground Elevation at Surface of Hole _____

Location (Identify on Plan) _____

2. Land Use: FIELD (e.g. woodland, agricultural field, vacant lot, etc.)

Vegetation grasses Landform _____ Surface Stones NO Slope (%) A

Position on landscape (attach sheet)

3. Distances from: Open Water Body _____ feet Drainage Way _____ feet Possible Wet Area 40 feet

Property Line _____ feet Drinking Water Well _____ feet Other _____

4. Parent Material: Glacial Outwash

If Yes: Disturbed Soil ☐ Fill Material ☐ Impervious Layer(s) ☐ Unsuitable Materials Present: Yes ☐ No ☑

Weathered/Fractured Rock ☐ Bedrock ☐

5. Groundwater Observed: Yes ☑ No ☐

If Yes: Depth Weeping from Pit 68 Depth Standing Water in Hole 68

Estimated Depth to High Groundwater: 68 inches _____ elevation

Commonwealth of Massachusetts
City/Town of LITTLETON

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Deep Observation Hole Number: 467

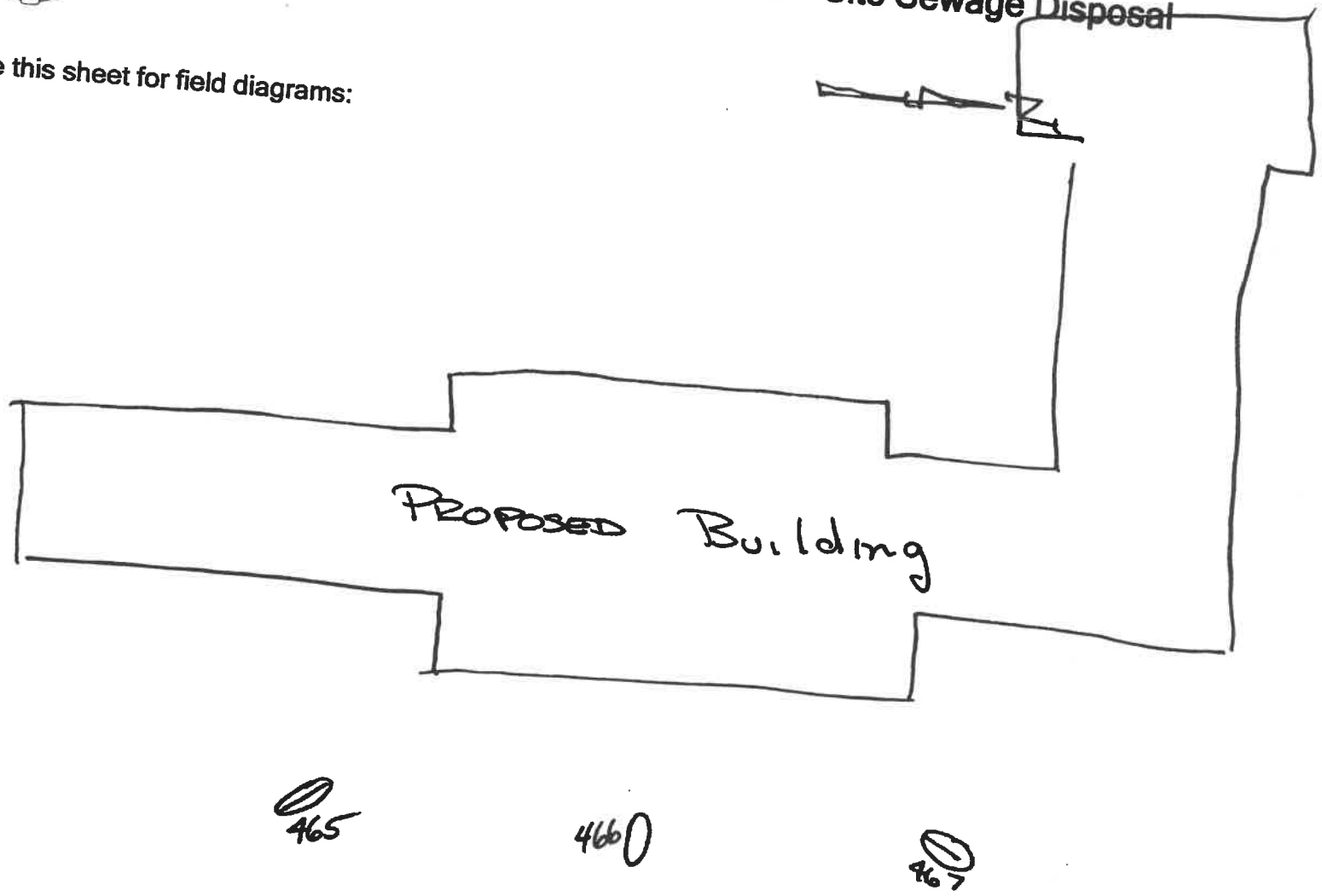
Depth (In.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features (mottles)			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0-10	C_1	10YR 5/6				gr CS	25	0%	sg	mvfr	
10-72	C_2	2.5Y 6/3	68			CS	35	0%	sg	mvfr	
72-90	C_3	10YR 4/4				vy gr cy	50	0%	sg	mvfr	

Additional Notes

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

Use this sheet for field diagrams:

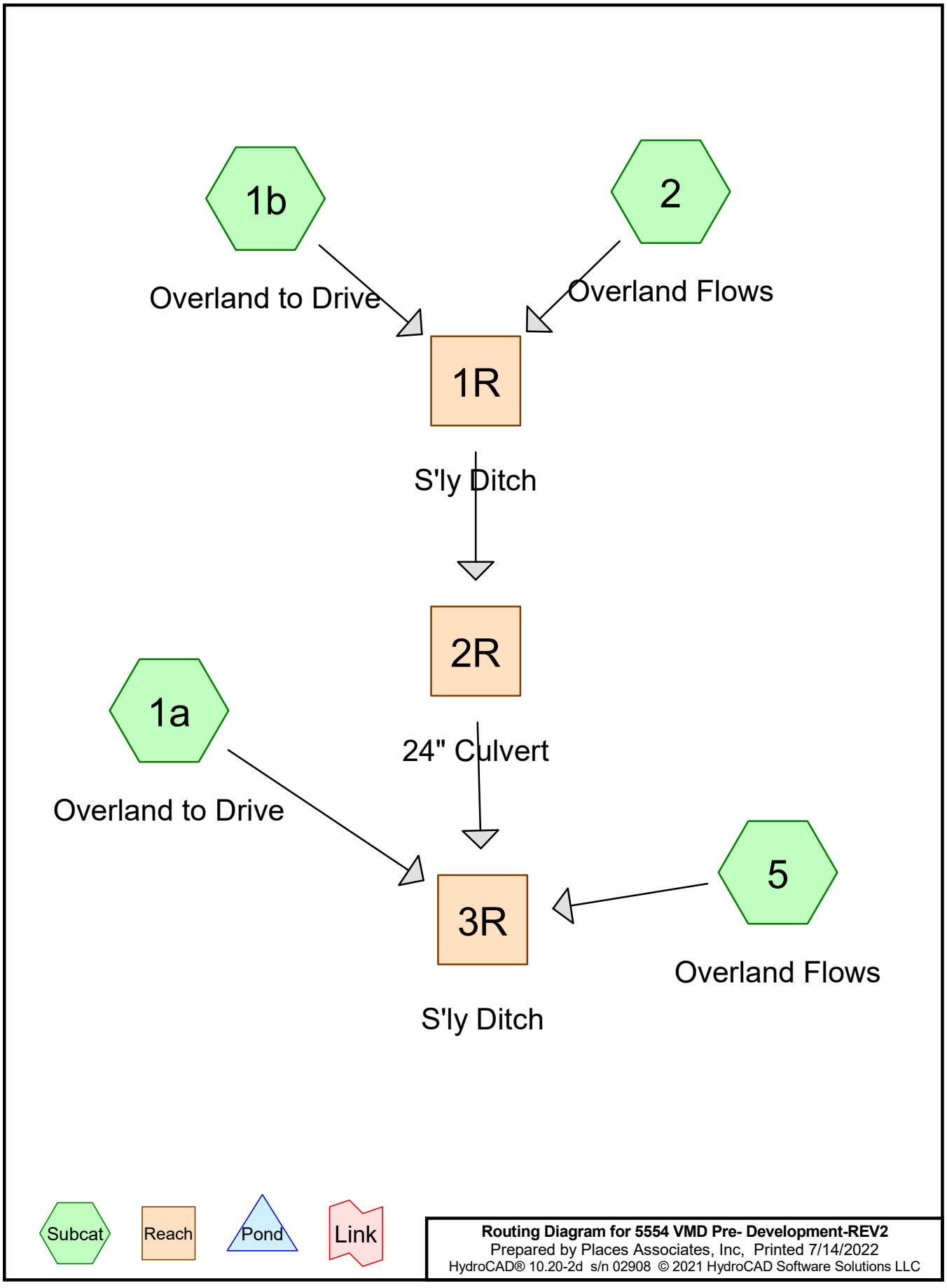


HydroCAD Data

PRE-DEVELOPMENT

DRAINAGE CALCULATIONS

256 Great Road, Suite 4, Littleton MA 01460 · (978) 486-0334 · www.placesassociates.com



Routing Diagram for 5554 VMD Pre- Development-REV2
Prepared by Places Associates, Inc, Printed 7/14/2022
HydroCAD® 10.20-2d s/n 02908 © 2021 HydroCAD Software Solutions LLC

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-yr	NRCC 24-hr	D	Default	24.00	1	3.19	2
2	10-yr	NRCC 24-hr	D	Default	24.00	1	4.92	2
3	100-yr	NRCC 24-hr	D	Default	24.00	1	7.66	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
9,500	39	>75% Grass cover, Good, HSG A (1a, 1b, 2)
279,675	48	Brush, Poor, HSG A (1a, 1b, 2, 5)
5,325	72	Dirt roads, HSG A (1a, 1b, 2, 5)
71,115	36	Woods, Fair, HSG A (1a, 1b, 2, 5)
365,615	**46**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
365,615	HSG A	1a, 1b, 2, 5
0	HSG B	
0	HSG C	
0	HSG D	
0	Other	
365,615		**TOTAL AREA**

Summary for Subcatchment 1a: Overland to Drive

Runoff = 0.01 cfs @ 14.35 hrs, Volume= 213 cf, Depth= 0.11"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 2-yr Rainfall=3.19"

Area (sf)	CN	Description
575	36	Woods, Fair, HSG A
21,680	48	Brush, Poor, HSG A
375	39	>75% Grass cover, Good, HSG A
1,320	72	Dirt roads, HSG A
23,950	49	Weighted Average
23,950		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.1	95	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.3	50	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.5	266		3.00		**Direct Entry, Pipe Flow**
6.8	461	Total			

Summary for Subcatchment 1b: Overland to Drive

Runoff = 0.00 cfs @ 24.02 hrs, Volume= 41 cf, Depth= 0.03"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 2-yr Rainfall=3.19"

Area (sf)	CN	Description
2,300	36	Woods, Fair, HSG A
8,580	48	Brush, Poor, HSG A
4,700	39	>75% Grass cover, Good, HSG A
200	72	Dirt roads, HSG A
15,780	44	Weighted Average
15,780		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.4	115	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
3.3	405	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	65		3.00		**Direct Entry, Pipe flow**
9.0	635	Total			

Summary for Subcatchment 2: Overland Flows

Runoff = 0.03 cfs @ 22.24 hrs, Volume= 895 cf, Depth= 0.06"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 2-yr Rainfall=3.19"

Area (sf)	CN	Description
38,225	36	Woods, Fair, HSG A
144,680	48	Brush, Poor, HSG A
4,425	39	>75% Grass cover, Good, HSG A
3,165	72	Dirt roads, HSG A
190,495	46	Weighted Average
190,495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2	50	0.0240	0.37		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.7	115	0.0120	1.10		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
2.1	45	0.0013	0.36		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	20	0.2700	5.20		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
6.1	230	Total			

Summary for Subcatchment 5: Overland Flows

Runoff = 0.02 cfs @ 22.59 hrs, Volume= 484 cf, Depth= 0.04"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 2-yr Rainfall=3.19"

Area (sf)	CN	Description
30,015	36	Woods, Fair, HSG A
104,735	48	Brush, Poor, HSG A
640	72	Dirt roads, HSG A
135,390	45	Weighted Average
135,390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	50	0.0200	0.35		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
0.2	30	0.1100	3.32		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
7.4	280	0.0040	0.63		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	30	0.1600	4.00		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
10.1	390	Total			

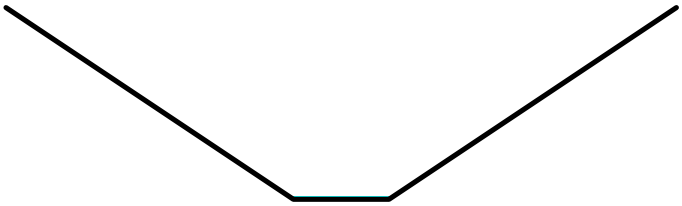
Summary for Reach 1R: S'ly Ditch

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth = 0.05" for 2-yr event
Inflow = 0.03 cfs @ 22.24 hrs, Volume= 936 cf
Outflow = 0.03 cfs @ 26.45 hrs, Volume= 856 cf, Atten= 2%, Lag= 252.6 min
Routed to Reach 2R : 24" Culvert

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.09 fps, Min. Travel Time= 145.6 min
Avg. Velocity = 0.07 fps, Avg. Travel Time= 176.9 min

Peak Storage= 238 cf @ 24.03 hrs
Average Depth at Peak Storage= 0.10' , Surface Width= 3.30'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 58.69 cfs

3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 750.0' Slope= 0.0007 '/'
Inlet Invert= 224.00', Outlet Invert= 223.46'



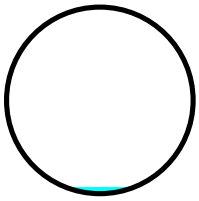
Summary for Reach 2R: 24" Culvert

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth > 0.05" for 2-yr event
Inflow = 0.03 cfs @ 26.45 hrs, Volume= 856 cf
Outflow = 0.03 cfs @ 26.50 hrs, Volume= 854 cf, Atten= 0%, Lag= 2.9 min
Routed to Reach 3R : S'ly Ditch

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.77 fps, Min. Travel Time= 2.3 min
Avg. Velocity = 0.64 fps, Avg. Travel Time= 2.7 min

Peak Storage= 4 cf @ 26.47 hrs
Average Depth at Peak Storage= 0.07' , Surface Width= 0.74'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 11.72 cfs

24.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 105.0' Slope= 0.0023 '/'
Inlet Invert= 223.46', Outlet Invert= 223.22'



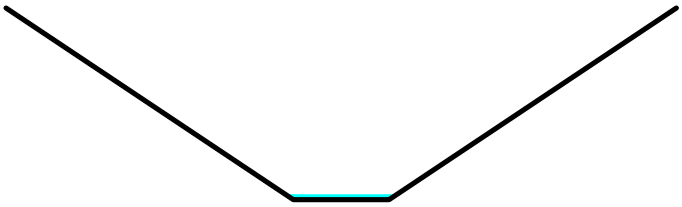
Summary for Reach 3R: S'ly Ditch

Inflow Area = 365,615 sf, 0.00% Impervious, Inflow Depth > 0.05" for 2-yr event
Inflow = 0.05 cfs @ 24.02 hrs, Volume= 1,550 cf
Outflow = 0.04 cfs @ 26.63 hrs, Volume= 1,169 cf, Atten= 8%, Lag= 156.6 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.08 fps, Min. Travel Time= 152.6 min
Avg. Velocity = 0.06 fps, Avg. Travel Time= 199.8 min

Peak Storage= 392 cf @ 24.09 hrs
Average Depth at Peak Storage= 0.17' , Surface Width= 3.52'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 38.78 cfs

3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 700.0' Slope= 0.0003 '/'
Inlet Invert= 223.22', Outlet Invert= 223.00'



Summary for Subcatchment 1a: Overland to Drive

Runoff = 0.22 cfs @ 12.16 hrs, Volume= 1,214 cf, Depth= 0.61"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 10-yr Rainfall=4.92"

Area (sf)	CN	Description
575	36	Woods, Fair, HSG A
21,680	48	Brush, Poor, HSG A
375	39	>75% Grass cover, Good, HSG A
1,320	72	Dirt roads, HSG A
23,950	49	Weighted Average
23,950		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.1	95	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.3	50	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.5	266		3.00		**Direct Entry, Pipe Flow**
6.8	461	Total			

Summary for Subcatchment 1b: Overland to Drive

Runoff = 0.03 cfs @ 12.29 hrs, Volume= 491 cf, Depth= 0.37"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 10-yr Rainfall=4.92"

Area (sf)	CN	Description
2,300	36	Woods, Fair, HSG A
8,580	48	Brush, Poor, HSG A
4,700	39	>75% Grass cover, Good, HSG A
200	72	Dirt roads, HSG A
15,780	44	Weighted Average
15,780		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.4	115	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
3.3	405	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	65		3.00		**Direct Entry, Pipe flow**
9.0	635	Total			

Summary for Subcatchment 2: Overland Flows

Runoff = 0.90 cfs @ 12.16 hrs, Volume= 7,339 cf, Depth= 0.46"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 10-yr Rainfall=4.92"

Area (sf)	CN	Description
38,225	36	Woods, Fair, HSG A
144,680	48	Brush, Poor, HSG A
4,425	39	>75% Grass cover, Good, HSG A
3,165	72	Dirt roads, HSG A
190,495	46	Weighted Average
190,495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2	50	0.0240	0.37		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.7	115	0.0120	1.10		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
2.1	45	0.0013	0.36		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	20	0.2700	5.20		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
6.1	230	Total			

Summary for Subcatchment 5: Overland Flows

Runoff = 0.38 cfs @ 12.26 hrs, Volume= 4,704 cf, Depth= 0.42"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 10-yr Rainfall=4.92"

Area (sf)	CN	Description
30,015	36	Woods, Fair, HSG A
104,735	48	Brush, Poor, HSG A
640	72	Dirt roads, HSG A
135,390	45	Weighted Average
135,390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	50	0.0200	0.35		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
0.2	30	0.1100	3.32		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
7.4	280	0.0040	0.63		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	30	0.1600	4.00		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
10.1	390	Total			

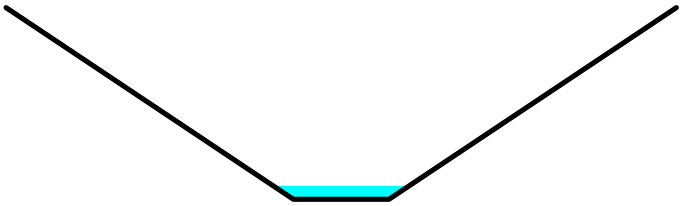
Summary for Reach 1R: S'ly Ditch

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth = 0.46" for 10-yr event
Inflow = 0.92 cfs @ 12.16 hrs, Volume= 7,830 cf
Outflow = 0.29 cfs @ 14.43 hrs, Volume= 7,739 cf, Atten= 68%, Lag= 136.2 min
Routed to Reach 2R : 24" Culvert

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.19 fps, Min. Travel Time= 64.8 min
Avg. Velocity = 0.13 fps, Avg. Travel Time= 95.1 min

Peak Storage= 1,139 cf @ 13.35 hrs
Average Depth at Peak Storage= 0.42' , Surface Width= 4.26'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 58.69 cfs

3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 750.0' Slope= 0.0007 '/'
Inlet Invert= 224.00', Outlet Invert= 223.46'



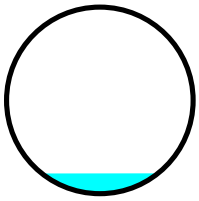
Summary for Reach 2R: 24" Culvert

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth > 0.45" for 10-yr event
Inflow = 0.29 cfs @ 14.43 hrs, Volume= 7,739 cf
Outflow = 0.29 cfs @ 14.46 hrs, Volume= 7,738 cf, Atten= 0%, Lag= 1.8 min
Routed to Reach 3R : S'ly Ditch

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 1.58 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 1.15 fps, Avg. Travel Time= 1.5 min

Peak Storage= 19 cf @ 14.45 hrs
Average Depth at Peak Storage= 0.22' , Surface Width= 1.25'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 11.72 cfs

24.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 105.0' Slope= 0.0023 '/'
Inlet Invert= 223.46', Outlet Invert= 223.22'



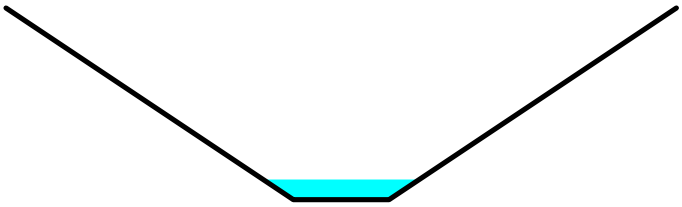
Summary for Reach 3R: S'ly Ditch

Inflow Area = 365,615 sf, 0.00% Impervious, Inflow Depth > 0.45" for 10-yr event
Inflow = 0.53 cfs @ 12.23 hrs, Volume= 13,656 cf
Outflow = 0.40 cfs @ 16.49 hrs, Volume= 13,282 cf, Atten= 25%, Lag= 255.6 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.16 fps, Min. Travel Time= 73.0 min
Avg. Velocity = 0.12 fps, Avg. Travel Time= 94.7 min

Peak Storage= 1,741 cf @ 15.27 hrs
Average Depth at Peak Storage= 0.63' , Surface Width= 4.89'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 38.78 cfs

3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 700.0' Slope= 0.0003 '/'
Inlet Invert= 223.22', Outlet Invert= 223.00'



Summary for Subcatchment 1a: Overland to Drive

Runoff = 1.07 cfs @ 12.15 hrs, Volume= 3,885 cf, Depth= 1.95"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 100-yr Rainfall=7.66"

Area (sf)	CN	Description
575	36	Woods, Fair, HSG A
21,680	48	Brush, Poor, HSG A
375	39	>75% Grass cover, Good, HSG A
1,320	72	Dirt roads, HSG A
23,950	49	Weighted Average
23,950		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.1	95	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.3	50	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.5	266		3.00		**Direct Entry, Pipe Flow**
6.8	461	Total			

Summary for Subcatchment 1b: Overland to Drive

Runoff = 0.43 cfs @ 12.17 hrs, Volume= 1,928 cf, Depth= 1.47"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 100-yr Rainfall=7.66"

Area (sf)	CN	Description
2,300	36	Woods, Fair, HSG A
8,580	48	Brush, Poor, HSG A
4,700	39	>75% Grass cover, Good, HSG A
200	72	Dirt roads, HSG A
15,780	44	Weighted Average
15,780		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.4	115	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
3.3	405	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	65		3.00		**Direct Entry, Pipe flow**
9.0	635	Total			

Summary for Subcatchment 2: Overland Flows

Runoff = 7.10 cfs @ 12.14 hrs, Volume= 26,272 cf, Depth= 1.65"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 100-yr Rainfall=7.66"

Area (sf)	CN	Description
38,225	36	Woods, Fair, HSG A
144,680	48	Brush, Poor, HSG A
4,425	39	>75% Grass cover, Good, HSG A
3,165	72	Dirt roads, HSG A
190,495	46	Weighted Average
190,495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2	50	0.0240	0.37		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.7	115	0.0120	1.10		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
2.1	45	0.0013	0.36		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	20	0.2700	5.20		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
6.1	230	Total			

Summary for Subcatchment 5: Overland Flows

Runoff = 3.86 cfs @ 12.19 hrs, Volume= 17,600 cf, Depth= 1.56"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 100-yr Rainfall=7.66"

Area (sf)	CN	Description
30,015	36	Woods, Fair, HSG A
104,735	48	Brush, Poor, HSG A
640	72	Dirt roads, HSG A
135,390	45	Weighted Average
135,390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	50	0.0200	0.35		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
0.2	30	0.1100	3.32		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
7.4	280	0.0040	0.63		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	30	0.1600	4.00		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
10.1	390	Total			

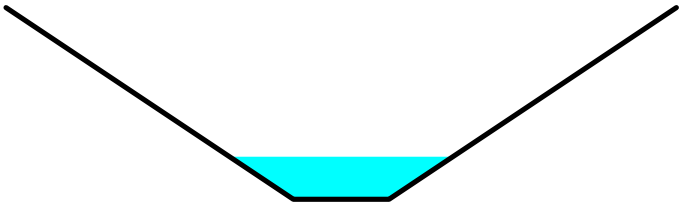
Summary for Reach 1R: S'ly Ditch

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth = 1.64" for 100-yr event
Inflow = 7.50 cfs @ 12.14 hrs, Volume= 28,200 cf
Outflow = 2.41 cfs @ 12.96 hrs, Volume= 28,102 cf, Atten= 68%, Lag= 48.9 min
Routed to Reach 2R : 24" Culvert

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.36 fps, Min. Travel Time= 34.8 min
Avg. Velocity = 0.18 fps, Avg. Travel Time= 68.7 min

Peak Storage= 5,020 cf @ 12.38 hrs
Average Depth at Peak Storage= 1.34' , Surface Width= 7.01'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 58.69 cfs

3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 750.0' Slope= 0.0007 '/'
Inlet Invert= 224.00', Outlet Invert= 223.46'



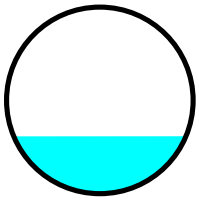
Summary for Reach 2R: 24" Culvert

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth > 1.63" for 100-yr event
Inflow = 2.41 cfs @ 12.96 hrs, Volume= 28,102 cf
Outflow = 2.41 cfs @ 12.97 hrs, Volume= 28,100 cf, Atten= 0%, Lag= 1.0 min
Routed to Reach 3R : S'ly Ditch

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.93 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 1.54 fps, Avg. Travel Time= 1.1 min

Peak Storage= 86 cf @ 12.96 hrs
Average Depth at Peak Storage= 0.61' , Surface Width= 1.85'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 11.72 cfs

24.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 105.0' Slope= 0.0023 '/'
Inlet Invert= 223.46', Outlet Invert= 223.22'



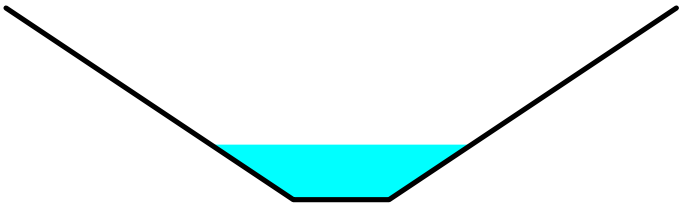
Summary for Reach 3R: S'ly Ditch

Inflow Area = 365,615 sf, 0.00% Impervious, Inflow Depth > 1.63" for 100-yr event
Inflow = 4.80 cfs @ 12.18 hrs, Volume= 49,585 cf
Outflow = 2.60 cfs @ 14.17 hrs, Volume= 49,220 cf, Atten= 46%, Lag= 119.3 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.27 fps, Min. Travel Time= 43.1 min
Avg. Velocity = 0.17 fps, Avg. Travel Time= 69.9 min

Peak Storage= 6,709 cf @ 13.45 hrs
Average Depth at Peak Storage= 1.72' , Surface Width= 8.15'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 38.78 cfs

3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 700.0' Slope= 0.0003 '/'
Inlet Invert= 223.22', Outlet Invert= 223.00'



25-YEAR Pre-Development - Detailed

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	25-yr	NRCC 24-hr	D	Default	24.00	1	6.00	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
9,500	39	>75% Grass cover, Good, HSG A (1a, 1b, 2)
279,675	48	Brush, Poor, HSG A (1a, 1b, 2, 5)
5,325	72	Dirt roads, HSG A (1a, 1b, 2, 5)
71,115	36	Woods, Fair, HSG A (1a, 1b, 2, 5)
365,615	**46**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
365,615	HSG A	1a, 1b, 2, 5
0	HSG B	
0	HSG C	
0	HSG D	
0	Other	
365,615		**TOTAL AREA**

Summary for Subcatchment 1a: Overland to Drive

Runoff = 0.51 cfs @ 12.15 hrs, Volume= 2,139 cf, Depth= 1.07"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 25-yr Rainfall=6.00"

Area (sf)	CN	Description
575	36	Woods, Fair, HSG A
21,680	48	Brush, Poor, HSG A
375	39	>75% Grass cover, Good, HSG A
1,320	72	Dirt roads, HSG A
23,950	49	Weighted Average
23,950		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.1	95	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.3	50	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.5	266		3.00		**Direct Entry, Pipe Flow**
6.8	461	Total			

Summary for Subcatchment 1b: Overland to Drive

Runoff = 0.15 cfs @ 12.19 hrs, Volume= 970 cf, Depth= 0.74"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 25-yr Rainfall=6.00"

Area (sf)	CN	Description
2,300	36	Woods, Fair, HSG A
8,580	48	Brush, Poor, HSG A
4,700	39	>75% Grass cover, Good, HSG A
200	72	Dirt roads, HSG A
15,780	44	Weighted Average
15,780		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.9	50	0.0060	0.21		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.4	115	0.0200	1.41		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
3.3	405	0.0100	2.03		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.4	65		3.00		**Direct Entry, Pipe flow**
9.0	635	Total			

Summary for Subcatchment 2: Overland Flows

Runoff = 2.99 cfs @ 12.15 hrs, Volume= 13,757 cf, Depth= 0.87"
Routed to Reach 1R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 25-yr Rainfall=6.00"

Area (sf)	CN	Description
38,225	36	Woods, Fair, HSG A
144,680	48	Brush, Poor, HSG A
4,425	39	>75% Grass cover, Good, HSG A
3,165	72	Dirt roads, HSG A
190,495	46	Weighted Average
190,495		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.2	50	0.0240	0.37		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
1.7	115	0.0120	1.10		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
2.1	45	0.0013	0.36		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	20	0.2700	5.20		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
6.1	230	Total			

Summary for Subcatchment 5: Overland Flows

Runoff = 1.48 cfs @ 12.20 hrs, Volume= 9,040 cf, Depth= 0.80"
Routed to Reach 3R : S'ly Ditch

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
NRCC 24-hr D 25-yr Rainfall=6.00"

Area (sf)	CN	Description
30,015	36	Woods, Fair, HSG A
104,735	48	Brush, Poor, HSG A
640	72	Dirt roads, HSG A
135,390	45	Weighted Average
135,390		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
2.4	50	0.0200	0.35		**Sheet Flow,** Fallow n= 0.050 P2= 3.00"
0.2	30	0.1100	3.32		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
7.4	280	0.0040	0.63		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
0.1	30	0.1600	4.00		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
10.1	390	Total			

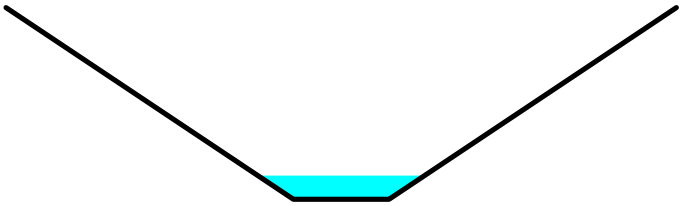
Summary for Reach 1R: S'ly Ditch

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth = 0.86" for 25-yr event
Inflow = 3.12 cfs @ 12.15 hrs, Volume= 14,727 cf
Outflow = 0.81 cfs @ 13.43 hrs, Volume= 14,634 cf, Atten= 74%, Lag= 76.9 min
Routed to Reach 2R : 24" Culvert

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.26 fps, Min. Travel Time= 47.3 min
Avg. Velocity = 0.16 fps, Avg. Travel Time= 80.1 min

Peak Storage= 2,295 cf @ 12.64 hrs
Average Depth at Peak Storage= 0.74' , Surface Width= 5.23'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 58.69 cfs

3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 750.0' Slope= 0.0007 '/'
Inlet Invert= 224.00', Outlet Invert= 223.46'



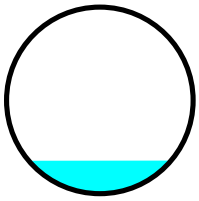
Summary for Reach 2R: 24" Culvert

Inflow Area = 206,275 sf, 0.00% Impervious, Inflow Depth > 0.85" for 25-yr event
Inflow = 0.81 cfs @ 13.43 hrs, Volume= 14,634 cf
Outflow = 0.81 cfs @ 13.45 hrs, Volume= 14,632 cf, Atten= 0%, Lag= 1.4 min
Routed to Reach 3R : S'ly Ditch

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 2.14 fps, Min. Travel Time= 0.8 min
Avg. Velocity = 1.34 fps, Avg. Travel Time= 1.3 min

Peak Storage= 40 cf @ 13.44 hrs
Average Depth at Peak Storage= 0.36' , Surface Width= 1.53'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 11.72 cfs

24.0" Round Pipe
n= 0.012 Concrete pipe, finished
Length= 105.0' Slope= 0.0023 '/'
Inlet Invert= 223.46', Outlet Invert= 223.22'



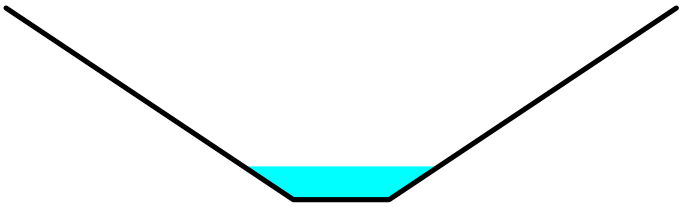
Summary for Reach 3R: S'ly Ditch

Inflow Area = 365,615 sf, 0.00% Impervious, Inflow Depth > 0.85" for 25-yr event
Inflow = 1.90 cfs @ 12.19 hrs, Volume= 25,811 cf
Outflow = 0.99 cfs @ 15.12 hrs, Volume= 25,446 cf, Atten= 48%, Lag= 175.9 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-30.00 hrs, dt= 0.01 hrs
Max. Velocity= 0.21 fps, Min. Travel Time= 56.0 min
Avg. Velocity = 0.15 fps, Avg. Travel Time= 80.2 min

Peak Storage= 3,316 cf @ 14.18 hrs
Average Depth at Peak Storage= 1.04' , Surface Width= 6.12'
Bank-Full Depth= 6.00' Flow Area= 72.0 sf, Capacity= 38.78 cfs

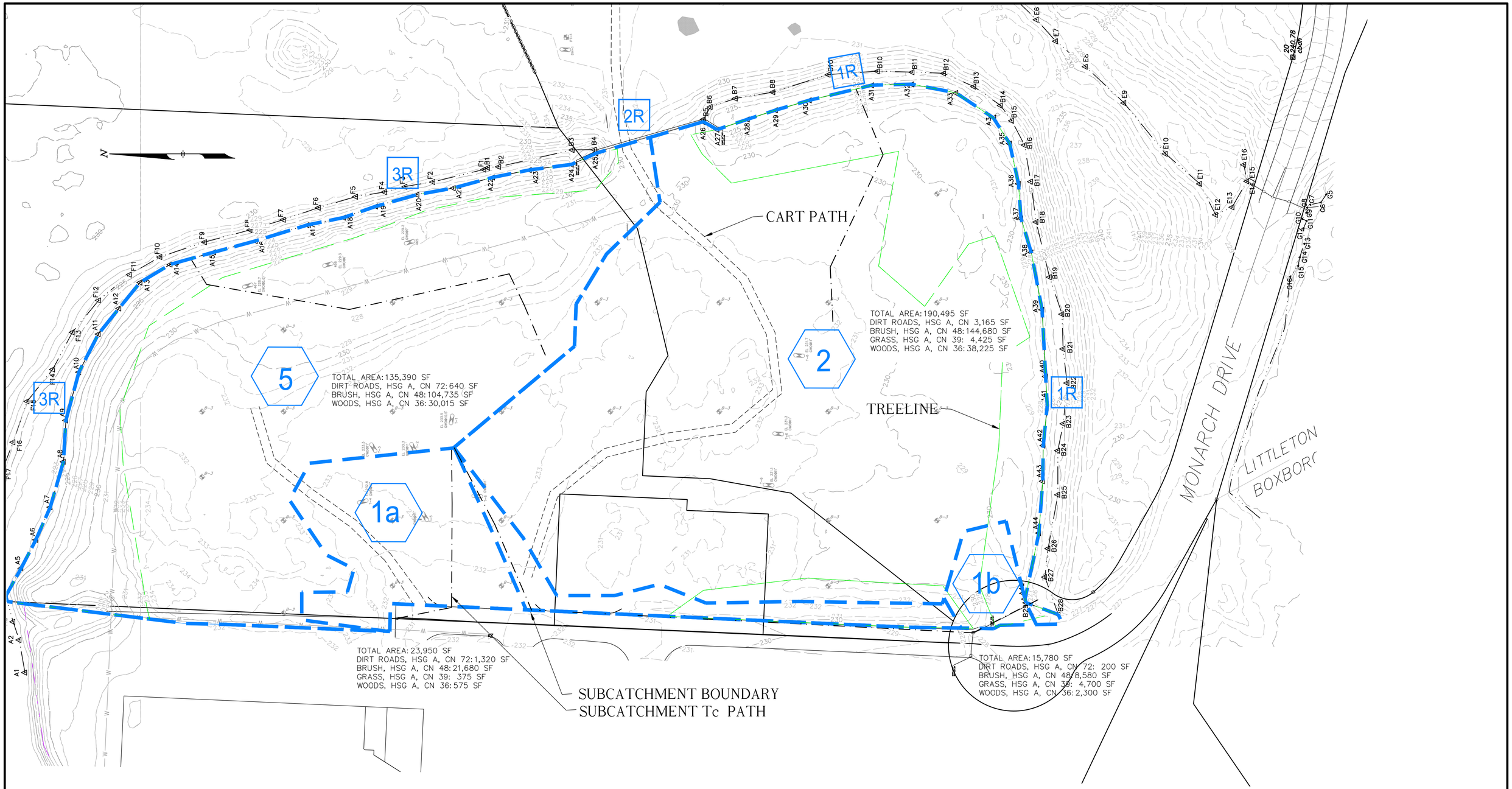
3.00' x 6.00' deep channel, n= 0.100 Earth, dense brush, high stage
Side Slope Z-value= 1.5 '/' Top Width= 21.00'
Length= 700.0' Slope= 0.0003 '/'
Inlet Invert= 223.22', Outlet Invert= 223.00'



POST-DEVELOPMENT

DRAINAGE CALCULATIONS

PLACES Associates, Inc.
256 Great Road, Suite 4, Littleton MA 01460 · (978) 486-0334 · www.placesassociates.com



2 SUBCATCHMENT NUMBER

4 REACH NUMBER

10 POND NUMBER

40' 0 40' 80'

BAR SCALE
1"=40'
CHECK GRAPHIC SCALE BEFORE USING

REVISIONS
06-24-22 PEER REVIEW COMMENTS
07-14-22 PEER REVIEW COMMENTS
07-28-22 NO REVISIONS THIS SHEET

PRE DEVELOPMENT DRAINAGE PLAN

LOCATION: MONARCH DRIVE
CITY/TOWN: LITTLETON, MASSACHUSETTS
PREPARED FOR:

VMD INDUSTRIES V LLC

SCALE: 1"=60' DATE: APRIL 2022

PLACES Associates, Inc.
· Planning
· Landscape Architecture
· Civil Engineering
· Surveying
256 Great Road, Suite 4
Littleton, MA 01460
(978) 486-0334
www.placesassociates.com

PROJECT No.: 5554 PLAN No.: 5554-PRE

TOTAL AREA: 19,435 SF
PAVED, HSG A, CN 98: 850 SF
GRASS, HSG A, CN 39: 18,585 SF

TOTAL AREA: 19,435 SF
PAVED, HSG A, CN 98: 850 SF
GRASS, HSG A, CN 39: 18,585 SF

NATURAL OVERFLOW
ELEV=228.65±

TREELINE

TOTAL AREA: 48,165 SF
IMP. ROOF, HSG A, CN 98: 48,165 SF

TOTAL AREA: 49,985 SF
IMP. ROOF, HSG A, CN 98: 49,985 SF

TOTAL AREA: 23,610 SF
PAVED, HSG A, CN 98: 15,460 SF
GRASS, HSG A, CN 39: 8,150 SF

TOTAL AREA: 18,930 SF
PAVED, HSG A, CN 98: 18,930 SF

TOTAL AREA: 42,945 SF
BRUSH, HSG A, CN 48: 10,610 SF
WOODS, HSG A, CN 36: 32,335 SF

TOTAL AREA: 9,575 SF
PAVED, HSG A, CN 98: 7,375 SF
GRASS, HSG A, CN 39: 2,200 SF

TOTAL AREA: 16,600 SF
PAVED, HSG A, CN 98: 14,955 SF
GRASS, HSG A, CN 39: 1,645 SF

TOTAL AREA: 3,645 SF
PAVED, HSG A, CN 98: 2,165 SF
GRASS, HSG A, CN 39: 1,480 SF

TOTAL AREA: 6,750 SF
PAVED, HSG A, CN 98: 6,750 SF

TOTAL AREA: 5,765 SF
PAVED, HSG A, CN 98: 2,890 SF
GRASS, HSG A, CN 39: 2,875 SF

TOTAL AREA: 26,215 SF
PAVED, HSG A, CN 98: 20,410 SF
GRASS, HSG A, CN 39: 5,805 SF

TOTAL AREA: 22,770 SF
PAVED, HSG A, CN 98: 14,620 SF
GRASS, HSG A, CN 39: 8,150 SF

TOTAL AREA: 43,725 SF
BRUSH, HSG A, CN 48: 14,895 SF
WOODS, HSG A, CN 36: 28,830 SF

2 SUBCATCHMENT NUMBER

4 REACH NUMBER

10 POND NUMBER

40' 0 40' 80'
BAR SCALE
1"=40'
CHECK GRAPHIC SCALE BEFORE USING

REVISIONS
06-24-22 PEER REVIEW COMMENTS
07-14-22 PEER REVIEW COMMENTS
07-28-22 NO REVISIONS THIS SHEET

POST DEVELOPMENT DRAINAGE PLAN

LOCATION: MONARCH DRIVE
CITY/TOWN: LITTLETON, MASSACHUSETTS
PREPARED FOR:

VMD INDUSTRIES V LLC

SCALE: 1"=60' DATE: APRIL 2022

PLACES Associates, Inc.
· Planning
· Landscape Architecture
· Civil Engineering
· Surveying
256 Great Road, Suite 4
Littleton, MA 01460
(978) 486-0334
www.placesassociates.com

PROJECT No.: 5554 PLAN No.: 5554-POST