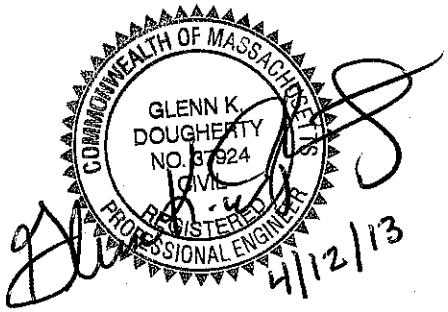
Stormwater Management Report and Environmental Impact Analysis

Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Submitted to:
Needham Board of Appeals

April 12, 2013



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1.0 Introduction

This Stormwater Management Report, prepared in accordance with DEP Stormwater Management Standards, is submitted to the Town of Needham on behalf of the applicant, Greendale Avenue Venture LLC, c/o Mill Creek Residential Trust LLC, 15 New England Industrial Park, Burlington, Massachusetts, for a proposed site development known as "Needham Mews". The project under Massachusetts General Laws, Chapter 40B is a 300-unit rental apartment community located on a 6.02-acre site at 692 & & 744 Greendale Avenue, Figure 1, *USGS Locus Map*. This report supplements the set of plans prepared by this office and submitted to the Town of Needham, entitled, "Comprehensive Permit Preliminary Site Plans, Needham Mews, 692 & & 744 Greendale Avenue, Needham, MA".

The site consists of three parcels (Assessors Map 18, Parcels 42, 43 & 44) within the Single Residence A Zoning District. It is bounded by the Route 128/I-95 highway to the northeast, the Greendale Worship Center to the southeast, Greendale Avenue to the southwest, and "Hardy Street" to the northwest. Hardy Street is listed as an ancient and abandoned town way; it is overgrown with vegetation and passable only by foot. Access to the site is from Greendale Avenue, a public way. There is no access to the site from Route 128.

Two of the site parcels consist of single-family residences: the 1.00 acre property at 692 Greendale Avenue and the 0.58 acre property at 744 Greendale Avenue. The remainder of the site, 4.44 acres, consists of undeveloped woodlands and sloping topography with an elevation differential of approximately 50 feet between high side of the lot at Greendale Avenue and the bottom of slope near Route 128. A 20' wide Town sewer easement with an 8" diameter sewer pipe bisects the undeveloped wooded portion of the site from Greendale Avenue connecting to a manhole and 21" diameter sewer pipe that runs parallel to Route 128.

The proposed development consists of five 4-story and 5-story apartment buildings, access drives, surface and under-building parking garages, 510 parking spaces (470 garage spaces and 40 surface spaces), waste/recycle enclosure areas located within the parking garages, sidewalks, site lighting, landscaping, stormwater management system and utility infrastructure. The existing sewer pipe and easement is proposed to be relocated around the perimeter of the development along the easterly lot line. Sewer, storm drain, water, gas, electric and telecommunication utilities are available in Greendale Avenue. The proposed stormwater management facilities will incorporate water quality and quantity control features and best management practices (BMP's) in conformance with DEP Stormwater Management Standards.

1.1 Environmental Impact Analysis

Per Town of Needham Comprehensive Permit Rules of the Board of Appeals, Adopted September 15, 2011, under Article III. Section 1. (b) (i), an "Environmental Impact Analysis" prepared by a qualified environmental scientist, professional wetland scientist (PWS), certified soil scientist, botanist, hydrogeologist and/or scientific professional with demonstrated qualifications is required as part of the submission to the Board of Appeals. It shall assess the impact of the development on the environment within the development and adjacent thereto. Such analysis shall include, but shall not be limited to, an evaluation of pre-development

conditions and post-development impacts. Such analysis shall include proposed mitigation of any identified post-development impacts. Mitigation measures requiring continuing or periodic maintenance shall be identified and a proposed maintenance plan shall be included with the Environmental Impact Analysis.

The Environmental Impact Analysis (EIA) prepared by Tetra Tech personnel, and more specifically, by Edward Hutchinson, a Professional Wetland Scientist (PWS) and Glenn Dougherty, a certified soil scientist and Professional Engineer, is included in this Stormwater Management Report and submitted to the Town of Needham as part of the Comprehensive Permit Application filing with the Board of Appeals. All of the information required in the EIA as stated in the above paragraph are found in this Stormwater Management Report, including a hydrologic evaluation of pre-development versus post-development conditions found in Appendix B; proposed stormwater management mitigation measures of the potential post-development impacts in the form of best management practices (BMP's) as described in sections 2.0 and 3.0; and a proposed maintenance plan for the BMP mitigation measures, i.e., the Operations and Maintenance Plan, found in Appendix F.

Ed Hutchinson, Tetra Tech's PWS conducted an initial inspection of the project site for the presence of wetland resource areas on the above referenced site in June, 2011. The site was investigated for the presence of hydrophytic (wetland) vegetation, hydric (wetland) soils, and wetland hydrology. The wooded site is dominated by red oak (*Quercus rubra*) and white pine (*Pinus strobus*) trees and saplings, with the occasional American beech (*Fagus grandifolia*). These species are considered Facultative Upland (FACU), which indicates that they usually occur in non-wetlands, but occasionally can be found in wetlands. The soils on the site did not exhibit hydric soil characteristics and no evidence of wetland hydrology was observed. There was no evidence of standing or ponded water, the soils were not saturated, nor was there any indication of high groundwater. Some low lying areas were observed in portions of the site; however, these areas did not support hydrophytic vegetation, nor did they contain hydric soils or exhibit indicators of wetland hydrology.

Massachusetts Department of Environmental Protection's (DEP) wetlands layer found in the Massachusetts Geographic Information System (MassGIS) data base indicate no wetland resource areas or hydrologic connections at all on the subject site, consistent with our field observations. However, mapping from the Town of Needham GIS data base indicates the presence of three intermittent streams on and adjacent to the project site, which in our professional opinion, appears to be inconsistent with the DEP/MassGIS wetlands data base and with Tetra Tech's findings from the initial site inspection.

Mr. Hutchinson conducted a second site inspection on March 13, 2013 to further investigate the specific areas depicted as intermittent streams on the Needham GIS map. Utilizing a hand auger to check for the presence of hydric soils and a visual inspection of the area for the presence of wetlands species and other indicators did not produce any evidence of two of the three intermittent streams—the two shown on the Needham GIS map as being on the project site and within the State Highway Layout adjacent to the project site. However, one intermittent stream was found during the site inspection. This intermittent stream, as shown on the Needham GIS map, is located on the property of the Greendale Worship Center at the base of the hill adjacent to Route 128. It is important to note that the proposed limits of the Needham Mews development

as designed is more than 100 feet from the closest portion of this intermittent stream as shown on the Site Plans. In summary, two of the three intermittent streams shown on the Needham GIS are not jurisdictional under the Massachusetts Wetlands Protection Act because they do not meet the criteria for an intermittent stream and because no resource areas are present; and the one intermittent stream that does exist on an abutting property does not affect the proposed residential development at 692 & 744 Greendale Avenue. A memorandum report summarizing these findings was submitted to Patricia Barry, Conservation Department Director, on March 29, 2013.

FEMA mapping was reviewed to determine if there are any flood zones located on the project site. According to the published FEMA mapping, there are not any portions of the site shown as being within a 100 year flood zone. Along the north side of Route 128, there is an extensive flood zone associated with the Charles River, however this flood zone does not cross to the south side of Route 128 and therefore does not affect the property. Refer to Figure 3, *FEMA Flood Boundaries.*

Natural Heritage and Endangered Species Program (NHESP) mapping was reviewed to determine if there are any areas on or near the site with Areas of Critical Environmental Concern (ACEC) such as vernal pools, estimated habitat for rare wildlife and priority habitat sites for rare species. According to the published NHESP mapping, there are not any portions of the site shown as being within any ACEC's. Refer to Figure 4, *Reserved and Protected Areas.*

The site is not located in or near any public water supply area, surface water protection area or Title V 100' buffer zones. Refer to Figure 5, *Public Water Supplies* and Figure 6, *Title V Buffer Areas.* Municipal water and sewer utilities provide services to the houses at 692 and 744 Greendale Avenue. Therefore, no environmental impacts associated with an on-site wastewater disposal system are applicable with the proposed development.

As described in Section 1.2 *Soils,* on-site evaluations were conducted for stormwater management design purposes by Glenn Dougherty, PE, Tetra Tech's DEP certified soil evaluator. The soil testing, which included several deep pit observations and percolation testing (refer to Appendix G *Soil Evaluation Logs*), resulted in excessively well-draining soils (as characterized in DEP soil evaluation criteria) of sand and gravel, particularly suitable for promoting infiltration of stormwater runoff.

In conformance with MA DEP Stormwater Handbook, best management practices (BMP's) were chosen for the design of the stormwater management system, including three subsurface infiltration/recharge areas which provide quantity controls and mitigation measures for potential post-development site impacts that could result due to increases in impervious surfaces and storm runoff. Based on a hydrologic evaluation of pre-development conditions and potential post-development impacts, the infiltration/recharge areas are designed to provide mitigation for potential post-development impacts during the 2-, 10-, 25- and 100-year storm events in order to meet DEP Standard #2, i.e., post-development peak discharge rates will not exceed pre-development peak discharge rates. In addition, the recharge areas are designed to meet the recharge volume requirements set forth in by Standard #3.

BMP's chosen as mitigation measures for water quality control consist of deep sump/hooded catch basins and water quality treatment units, as well as a pavement sweeping program. The water quality BMP's as designed meet the requirements for Standard #1- no new untreated

discharges; and Standard #4- 80% Total Suspended Solids (TSS) Rate of Removal. Mitigation measures requiring continuing or periodic maintenance for all quantity and quality control BMP's are identified in the Operations and Maintenance (O&M) Plan found in Appendix F. The purpose of the O&M Plan is to ensure periodic inspections of the BMP's; proper removal and disposal of accumulated sediments, oils, and debris; and implementation of corrective action and record keeping activities, meeting the requirement of Standard #9- implementation of a long-term Drainage Operations and Maintenance Plan.

In summary, this Environmental Impact Analysis addresses potential environmental impacts associated with the proposed residential development. Site investigations by a Professional Wetlands Scientist conclude that no resource areas exist on the project site or are affected by the project; soil testing by a DEP certified soil evaluator conclude that on-site soils are highly suitable for promoting stormwater infiltration and groundwater recharge; record research concludes that the site is not within or near any Areas of Critical Environment Concern, FEMA Flood Zone, Public Water Supply Area, Surface Water Protection Area or Title V Buffer Zone; and the proposed site stormwater management system was designed based on a hydrologic evaluation of pre-development conditions and post-development impacts, and includes proposed mitigation measures of impacts requiring periodic maintenance as outlined in the Operations and Maintenance Plan.

1.2 Soils

According to the Natural Resources Conservation Service (NRCS) Norfolk County Soil Survey, Dated 1989 the soils on site consist of the following (Refer to Figure 2, *Soils Map*):

- 5 – Saco Silt Loam, 0-3 percent slopes, Hydrologic Soil Group D
- 245B – Hinckley Sandy Loam, 3-8 percent slopes, Hydrologic Soil Group B
- 253D – Hinckley Loamy Sand, 15-35 percent slopes, Hydrologic Soil Group B
- 254B – Merrimac Fine Sandy Loam, 3-8 percent slopes, Hydrologic Group B

On-site soil evaluation testing was conducted on February 26-28, 2013 in the locations of the proposed stormwater management areas. Eight (8) deep observation test pits were excavated as identified on the Site Grading & Drainage Plan and evaluated by a Tetra Tech DEP certified Soils Evaluator (see soil logs, Appendix G).

Soils were evaluated for elevation of estimated seasonal high groundwater and suitability of the underlying soils to provide infiltrative capacity. In each of the deep pits, either very gravelly coarse sand or clean coarse sand were found. Percolation tests produced rapid rates of permeability, characteristic of excessively well-draining soils and categorized in Hydrologic Soil Group A. It has been determined that soils at this site are particularly suitable for subsurface infiltration/recharge systems.

1.3 Ground Cover

The total project site is 6.02 acres. To quantify contributory runoff from off-site areas, the hydrologic study area totals 7.54 acres.

Table 1-1 summarizes the ground cover distribution for the hydrologic study area for existing and proposed conditions. There is an increase of 3.64 acres (4.09 acres proposed-0.45 acres existing) in impervious area (pavement and roof) associated with the project. The numbers reflected in this report and the drainage calculations include the existing single-family house and driveway at 692 Greendale Avenue that is proposed to remain as part of the project; and the existing single-family house, detached garage and driveway at 744 Greendale Avenue that is proposed to be removed.

Table 1-1 Ground Cover - Hydrologic Area

Area	Existing (ac)	Proposed (ac)
Pavement/Roofs	0.45	4.09
Grass/Landscape	0.22	1.78
Woods	6.87	1.67
Total	**7.54**	**7.54**

2.0 Stormwater Management

2.1 Existing Stormwater Management

2.1.1 Existing Drainage System

Due to the nature of the existing development on the site (houses that are older than 50 years), there is no formalized drainage system. Stormwater runoff is conveyed through the site via overland flow. There are no stormwater quality features present on the site. A drainage system consisting of catch basins, manholes, and closed drainage pipe exists in Greendale Avenue.

2.1.2 Existing Watershed

For the analysis of existing storm water conditions the project area is divided into two (2) subcatchment areas. Characteristics of each subcatchment area are noted below and shown on Plan A.

There are two (2) points of analysis within the watershed:

- Reach 1R – Overland discharge near the eastern corner of the site.
- Reach 2R – Existing catch basin on Greendale Avenue

Subcatchment 1S consists of the majority of the proposed development site and portions of adjoining lots that contribute to stormwater runoff to Reach 1R. Containing 7.06 acres, this area

contains limited areas of residential development near Greendale Avenue, with the remainder of the area being pervious undeveloped woodland. The area slopes downward generally to the north, away from Greendale Avenue, towards the Route 128/I-95 right-of-way. Stormwater discharge is currently conveyed via overland flow and discharges near the northeastern corner of the site.

Subcatchment 2S consists of a small portion of the Greendale Avenue right-of-way and a narrow strip of the project site that surface drains towards Greendale Avenue (0.48 acres). This catchment area is comprised of impervious roadways with established drainage systems as well as pervious vegetated areas. The runoff from this subcatchment is collected via an existing catch basin that is part of the Greendale Avenue storm drainage system (2R).

2.1.3 Existing Runoff Calculations

In order to determine the peak rate of discharge for existing conditions, runoff hydrographs were generated for the storm events using the SCS TR-20 Method (refer to Appendix B, *HydroCAD® Input/Output*). Under existing conditions, runoff hydrographs were flood routed through the existing stormwater management facilities. The existing stormwater discharge rates are shown in Table 2-1.

Table 2-1 Existing Peak Runoff Rates

Point of Analysis	2-Year Storm (cfs)	10-Year Storm (cfs)	25-Year Storm (cfs)	100-Year Storm (cfs)
1R	1.03	4.54	7.06	11.30
2R	1.04	1.82	2.24	2.87

*cfs = cubic feet per second

2.2 Proposed Stormwater Management

2.2.1 Proposed Drainage System

The proposed drainage system consists of area drains, catch basins, manholes, HDPE high-density polyethylene pipes (sized for a 25-year storm), water quality treatment units and subsurface infiltration/recharge systems. Water quality treatment devices include four-foot deep sediment sumps and hoods at the outlets of the catch basins, Stormceptors water quality units, and subsurface infiltration/recharge systems utilizing Cultec Recharger 900HD chamber units. Site runoff from paved areas will be treated by the Stormceptor units prior to discharging to the Cultec chamber recharge areas. An overflow outlet from each of the three recharge areas is piped to a single discharge point located at an existing natural low-gradient area on the site near the northerly lot line by Route 128. The overall site stormwater management system conforms to all applicable DEP Standards, as listed in Section 3.0.

2.2.2 Proposed Watershed

For the analysis of proposed storm water conditions the project area is divided into five (5) subcatchment areas. Characteristics of each subcatchment area is noted below and shown on Plan B.

Subcatchments 1S and 2S consist of the area at the upper half of the site (closer to Greendale Avenue), including portions of proposed building roofs, site driveways and landscaped areas. The runoff from these areas is collected via roof drains and catch basins into closed drain pipes and conveyed to Subsurface Infiltration Areas 1 and 2, located beneath the drive aisle pavement in the middle of the site in front of Buildings E, F & G. Infiltration Area 1 consists of fifty (36) Cultec Recharger 900HD chambers; Infiltration Area 2 consists of thirty-three (66) chambers. Due to the grade change along the along the drive aisle, there is an elevation difference of approximately five feet between the infiltration areas. The two areas are hydraulically connected by a 12" diameter HDPE pipe. Subsurface Infiltration Areas 1 and 2 help mitigate the post-development runoff from the 2-, 10-, 25- and 100-year design storms to be less than the pre-development flow and is piped to an outlet located near the northerly lot line, this point of discharge being the Design Point of Analysis 1R.

Subcatchment 3S consists of the area at the lower half of the site (closer to Route 128), including the remaining portions of proposed building roofs, site driveways and landscape areas. The runoff from this subcatchment area is collected via yard drains and catch basins into closed drain pipes and conveyed to Subsurface Infiltration Area 3, consisting of seventy-five (75) Cultec Recharger 900HD chambers, located beneath the emergency access drive pavement located behind Buildings E, F and G. Subsurface Infiltration Area 3 also helps mitigate the post-development runoff from the 2-, 10-, 25- and 100-year design storms to be less than the pre-development flow which also discharges to Design Point 1R.

Subcatchment 4S consists of portions of the site and some offsite areas that are remaining in their present condition, no changes proposed. The runoff from this subcatchment flows via sheetflow and shallow concentrated flow to Design Point 1R.

Subcatchment 5S consists of a small portion of the Greendale Avenue right-of-way at the front of the project site. This catchment area is comprised mostly of the existing impervious roadway with established drainage systems, some vegetated areas along the street and a proposed concrete sidewalk along the site frontage. The runoff from this subcatchment is collected via an existing catch basin and storm drain system in Greendale Avenue, which is Design Point 2R. There is no increase in runoff proposed for Design Point 2R and the existing storm drain system in Greendale Avenue.

2.2.3 Proposed Runoff Calculations

In order to determine the peak rate of discharge for proposed conditions, runoff hydrographs were generated for the storm events using the SCS TR-20 Method (refer to Appendix B, *HydroCAD® Input/Output*). Under the proposed condition, runoff hydrographs were flood routed through the proposed stormwater management facilities. The proposed stormwater discharge rates are shown in Table 2-2.

Table 2-2 Proposed Peak Runoff Rates

Point of Analysis	2-Year Storm (cfs)	10-Year Storm (cfs)	25-Year Storm (cfs)	100-Year Storm (cfs)
1R	1.03	2.65	3.60	11.08
2R	1.04	1.79	2.20	2.80

*cfs = cubic feet per second

3.0 Stormwater Management Standards

The proposed stormwater management system complies with the Massachusetts Department of Environmental Protection (MADEP) Stormwater Management Policy. The project as designed will meet or exceed all of the ten (10) standards. The standards are described below.

3.1 Standard #1 – No New Untreated Discharges

No point discharges of untreated stormwater to resource areas are proposed. Stormwater quality control for the project includes street sweeping, deep sump/hooded catch basins, water quality treatment units and subsurface infiltration/recharge systems.

3.2 Standard #2 – Peak Rate Attenuation

Stormwater management controls were developed for the 2-, 10-, 25-, and 100-year 24-hour storm events. Under existing and proposed conditions, hydrologic analyses were performed utilizing the computer program, HydroCAD®. In order to determine the peak rate of discharge for existing and proposed conditions, runoff hydrographs were generated for the storm events using the SCS TR-20 Method (refer to Appendix B, *HydroCAD® Input/Output*). Under the proposed conditions, the post-development runoff hydrographs were flood routed through the proposed drainage collection system and into the proposed stormwater management system.

Table 3-1 summarizes the pre- and post-development peak runoff discharge rates determined in the hydrologic analyses performed for the Project.

Table 3-1 Comparison of Peak Runoff Rates

Point of Analysis	2-Year Storm (cfs)			10-Year Storm (cfs)			25-Year Storm (cfs)			100-Year Storm (cfs)		
	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ	Pre	Post	Δ
1R	1.03	1.03	-0.00	4.54	2.65	-1.89	7.06	3.60	-3.46	11.30	11.08	-0.22
2R	1.04	1.04	-0.00	1.82	1.79	-0.03	2.24	2.20	-0.04	2.87	2.80	-0.07

*cfs = cubic feet per second

As shown in Table 3-1, proposed peak runoff rates for the project are equal to or less than that of existing conditions for each storm event. The proposed site development project will not increase runoff rates at the points of analysis.

3.3 Standard #3 – Recharge

Soils encountered during the site testing conducted on February 26-28, 2013 in the proposed stormwater management areas are extremely well-draining gravelly coarse sand and classified as

Hydrologic Soil Group A (refer to Appendix G, *Soil Evaluation Logs*). Utilizing the Mass DEP Volume to Recharge table for Hydrologic Soil Group A (HSG A) soils, the required recharge volume is based on 0.60 inches of runoff times total impervious area.

The total proposed impervious area over the project site is 4.09 acres. Therefore, the required groundwater recharge volume is calculated as the following: [4.09 x (0.60/12)] = 0.205 acre-feet or 8,908 cubic feet. Referring to the Rawl's Table in the DEP Handbook, the infiltration/recharge areas are designed using an infiltration rate of 8.27 inches/hour recommended for HSG A soils. Using the most conservative "static" storage volume method, the recharge areas provide approximately 0.224 acre-feet or 9,765 cubic feet of static stormwater storage volume below the invert elevation of the overflow discharge pipe. The recharge systems will drain in less than 72 hours, and the required recharge volume (Standard #3) is met. Refer to Appendix C, *Groundwater Recharge Calculations,* for calculations.

3.4 Standard #4 – Water Quality

Best Management Practices (BMPs) will be used to provide water quality. The following BMPs will be provided on-site: street sweeping, deep sump hooded catch basins, Stormceptor water quality units, and Cultec subsurface infiltration/recharge systems. These BMPs will provide for greater than the required 80% TSS removal.

3.4.1 Street Sweeping

A comprehensive source reduction program of regular pavement sweeping, litter removal, and maintenance of trash areas will be implemented at the site to protect water quality by reducing the amount of sediment and pollutants entering the stormwater management system. The sweeping program will remove sand and contaminants directly from paved surfaces before they become mobilized during rain events and transported to the drainage system. Paved areas will be cleaned and maintained at least twice per year, typically in April and October and possibly more often as needed. In accordance with MADEP standards, a 10% TSS removal rate is credited for this BMP.

3.4.2 Deep Sump Catch Basins

All proposed catch basins on site will include four-foot deep sumps and provided with hooded outlets, which will serve to trap sediment and floatables before entering the drainage system. Catch basins will be inspected quarterly and cleaned when sediment reaches ½ full-depth to ensure that the catch basins are working in their intended purpose and free of debris. Sediments and hydrocarbons shall be properly handled and disposed of, in accordance with local, state, and federal requirements. A TSS removal credit of 25% is credited for this BMP.

3.4.3 Water Quality Units

The proposed design of the on-site drainage system will incorporate five (5) Stormceptor water quality units to provide treatment of runoff from pavement areas prior to discharging to the subsurface infiltration chambers. In accordance with MADEP standards a 50% TSS removal rate is credited for this BMP.

3.4.4 Subsurface Infiltration/Recharge Systems

There are three (3) subsurface infiltration systems which provide groundwater recharge of treated runoff prior to discharge. The systems consist of a series of Cultec Recharger 900HD chambers surrounded with double-washed stone and filter fabric. The systems have been designed to provide storage, infiltration, and additional filtration treatment of stormwater runoff. Runoff is directed through catch basins (with sumps) and Stormceptor water quality units prior to discharging into the infiltration systems. In accordance with MADEP standards an 80% TSS removal rate is credited for this BMP provided they are combined with one or more pretreatment BMPs prior to infiltration.

The incorporation of these BMP's will achieve a cumulative TSS removal rate of 92%, greater than the 80% minimum required by DEP. Refer to Appendix D, *Water Quality Calculations.*

3.5 Standard #5 – Land Uses with Higher Potential Pollutant Loads

The proposed site development project for a residential apartment community is not considered a land use with higher potential pollutant loads.

3.6 Standard #6 – Critical Areas

Critical areas are Outstanding Resource Waters (ORWs), shellfish beds, swimming beaches, cold water fisheries, and recharge areas for public drinking water supplies. No critical areas are located within the project.

3.7 Standard #7 – Redevelopment Standards only to the Maximum Extent Practicable

The proposed development project is not considered a redevelopment of an existing developed site. The stormwater management standards will be met in full for the proposed drainage system serving the site development.

3.8 Standard #8 – Construction Period Erosion and Sedimentation Control

Erosion and sediment control techniques will be employed during construction and earth moving phases of the work. Some of these include installation and maintenance of stabilized anti-tracking construction entrance, fiber roll and silt fence barriers, and catch basin protection with temporary catch basin filters and fiber roll barriers. The contractor will be responsible for implementing and maintaining each of these controls as shown on the Erosion Control Plan.

3.9 Standard #9 – Operations and Maintenance Plan

An Operation and Maintenance Plan for the project site has been prepared in accordance with DEP Stormwater Management Standard No. 9. A copy is presented in Appendix F.

The Stormwater Management System will be the overall responsibility of the Owner. The Owner will retain a Project Manager who will be responsible during construction. The Owner will be responsible for post-construction operation and maintenance.

3.10 Standard #10 – Prohibition of Illicit Discharges

Illicit discharges to the on-site stormwater management system and to the off-site existing municipal drainage system are prohibited. The project does not include any new off-site drainage connections to the existing municipal system. No illicit connections to the local drainage system or discharges to or from the on-site system will be made.

4.0 Site Hydraulics

The proposed drain pipe network is composed of catch basins and manholes that will collect runoff from the roadway, parking, building roof and landscaped areas within the proposed project area and discharge to the on-site infiltration/recharge systems.

The proposed storm drainage collection system has been designed for a 25-year storm frequency utilizing the Rational Method. StormCAD® was used to perform the hydraulic analysis for the storm drainage system (refer to Appendix D, *StormCAD Pipe Design Input/Output*).

The following criteria were used to design the pipe network for the proposed project:

- Pipes are sized to convey the 25-year storm event.
- Drainage pipes are High-Density Polyethelene (HDPE).
- Rainfall intensity of 6.0 inches per hour for 5-minute duration during the 25-year storm frequency.
- Manning's coefficient (n) of 0.013 for HDPE.
- Maximum pipe velocity is 10 feet per second (fps).

5.0 Conclusion

The Stormwater Management System addresses both the quantity control and quality of stormwater runoff from the site and meets or exceeds the requirements of the ten (10) standards outlined by the Massachusetts Department of Environmental Protection (DEP) Stormwater Policy.

TETRA TECH

One Grant Street
Framingham, MA 01701

USGS Map

692 & 744 Greendale Avenue
Needham, Massachusetts

3/27/13

Source: MassGIS, USGS

Figure 1

Created by: JLP

143-82806-13003 USGS.mxd

TETRA TECH
One Grant Street
Framingham, MA 01701

Site Aerial (2008)

692 &744 Greendale Avenue
Needham, Massachusetts

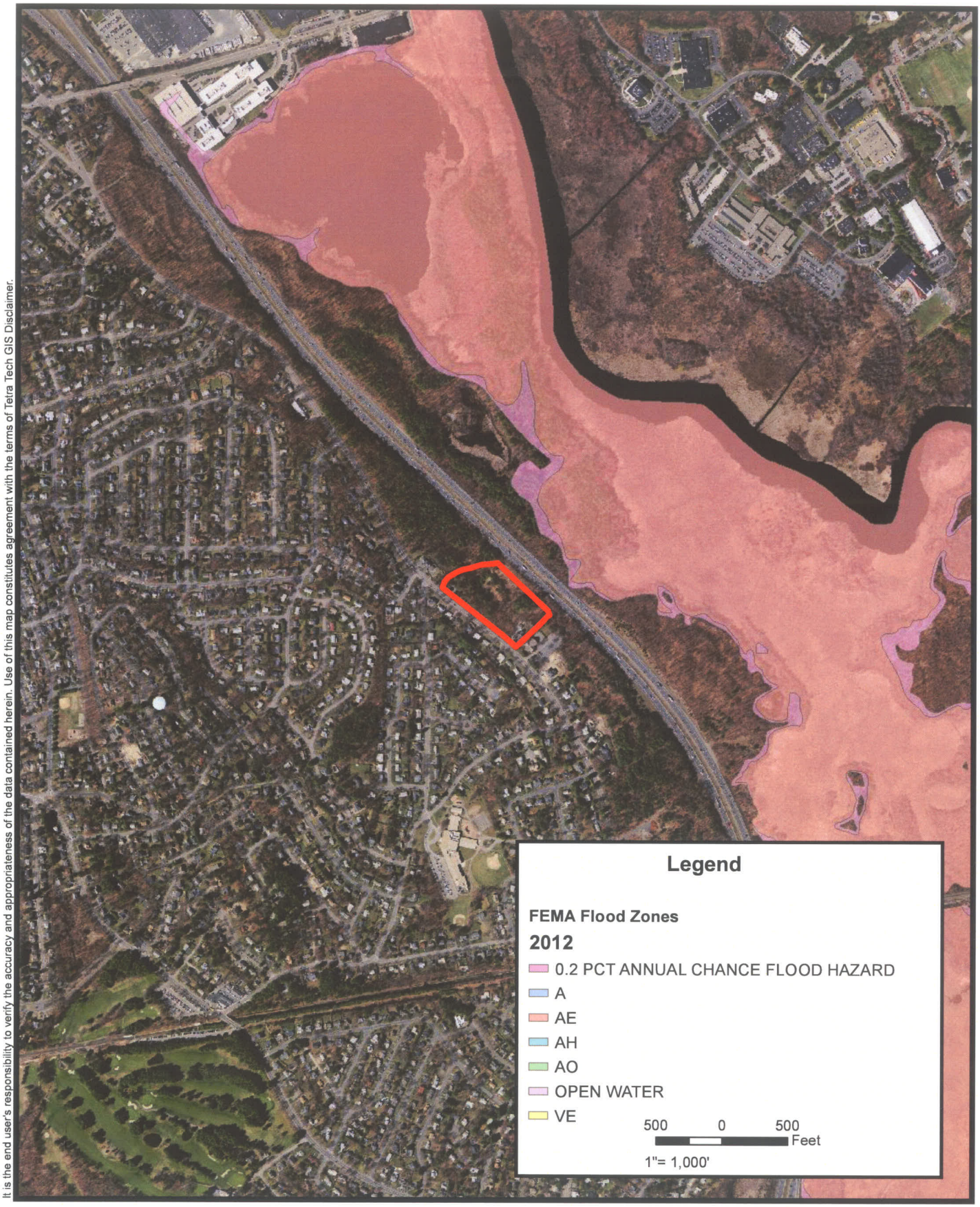
3/27/13

Source: MassGIS

Figure
2

Created by: JLP

143-82806-13003 Aerial.mxd



TETRA TECH

One Grant Street
Framingham, MA 01701

FEMA Flood Boundaries

692 & 744 Greendale Avenue
Needham, Massachusetts

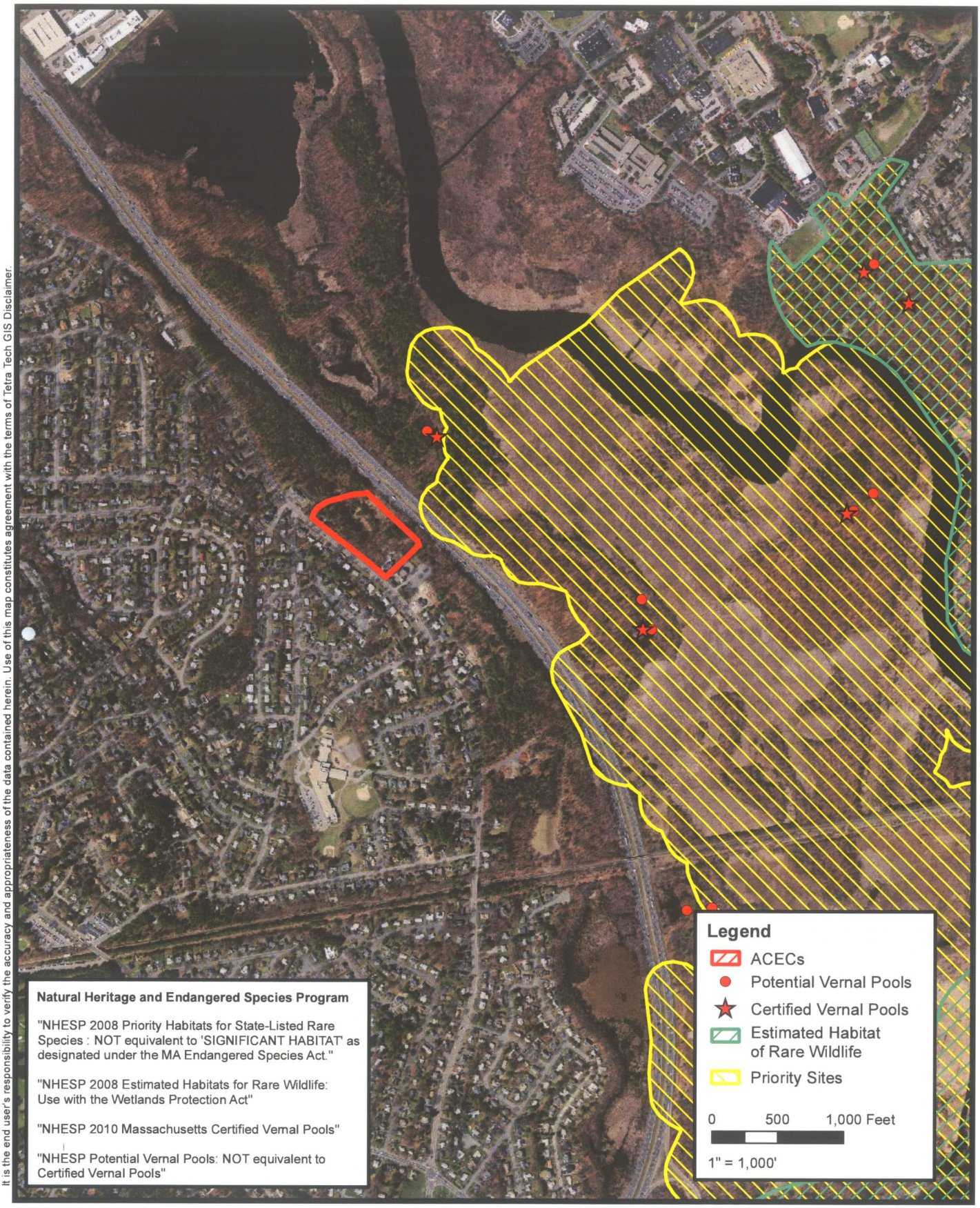
3/27/13

Source: MassGIS, FEMA

Figure 3

Created by: JLP

143-82806-13003 FEMA.mxd



TETRA TECH
One Grant Street
Framingham, MA 01701

Reserved and Protected Areas

692 & 744 Greendale Avenue
Needham, Massachusetts

3/27/13

Source: MassGIS, NHESP

Figure 4

Created by: JLP

143-82806-13003 NHESP.mxd

TETRA TECH
One Grant Street
Framingham, MA 01701

Public Water Supplies

692 & 744 Greendale Avenue
Needham, Massachusetts

3/27/13

Source: MassGIS, DEP

Figure 5

Created by: JLP

143-82806-13003 PWS.mxd

TETRA TECH
One Grant Street
Framingham, MA 01701

Title V Buffer Areas

692 & 744 Greendale Avenue
Needham, Massachusetts

3/27/13

Source: MassGIS, DEP

Figure 6

Created by: JLP

143-82806-13003 TITLE V.mxd

TETRA TECH

One Grant Street
Framingham, MA 01701

Wetland Resources (DEP 1:12,000)

692 & 744 Greendale Avenue
Needham, Massachusetts

3/27/13

Source: MassGIS, DEP

Figure 7

Created by: JLP

143-82806-13003 wetland.mxd

TETRA TECH
One Grant Street
Framingham, MA 01701

Soils Map

692 & 744 Greendale Avenue
Needham, Massachusetts

3/27/13

Source: MassGIS

Figure
8

Created by: JLP

143-82806-13003 Aerial.mxd

Appendix A

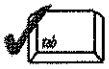
Stormwater Report Checklist

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

Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

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

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

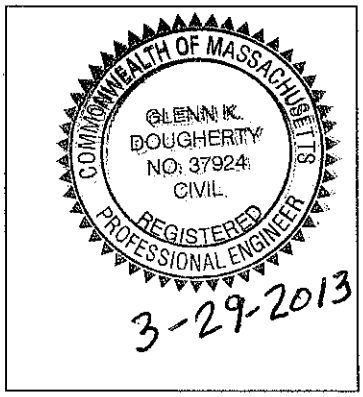
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



Signature and Date

Checklist

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

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 1: No New Untreated Discharges

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

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

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

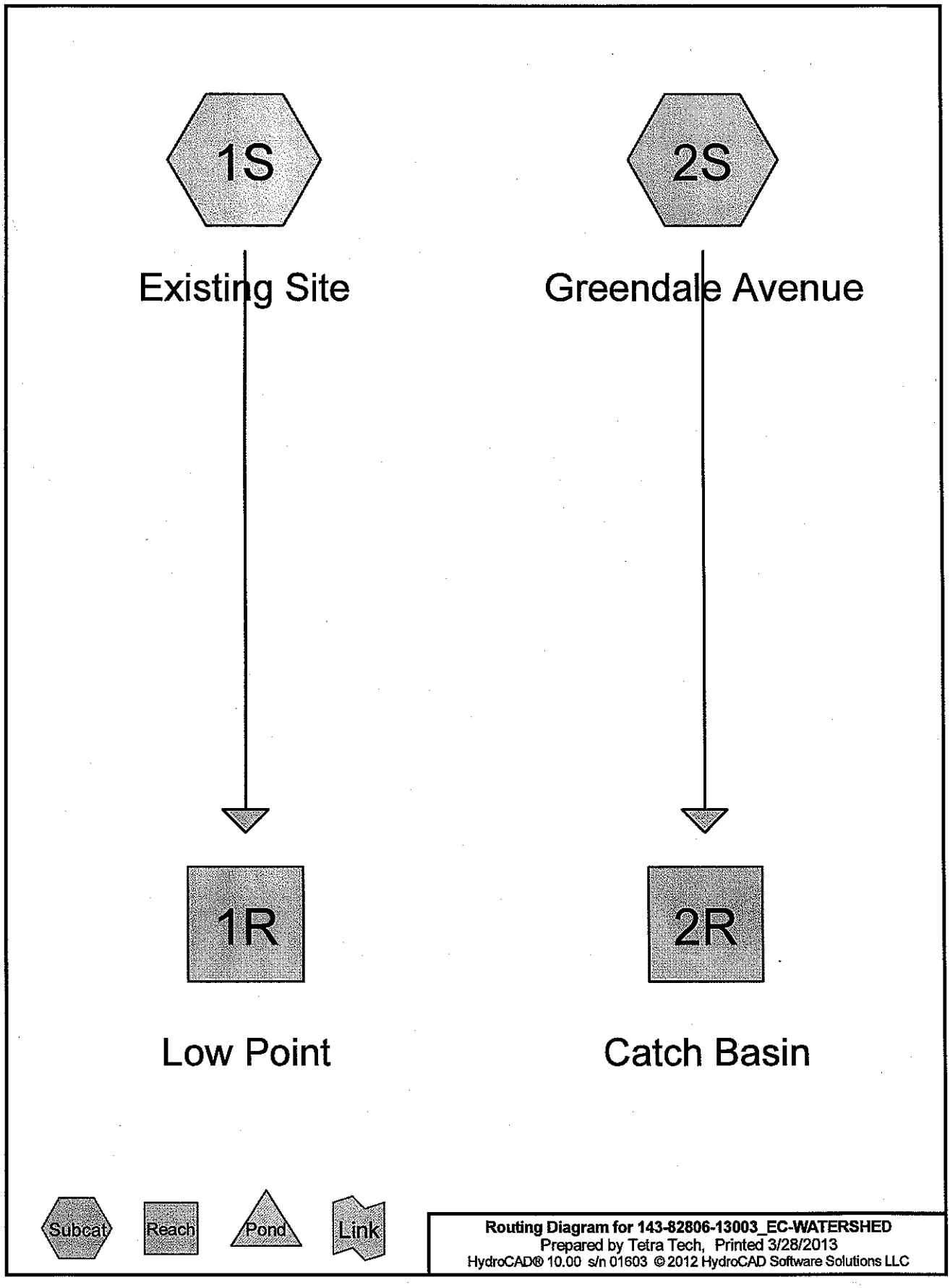
☐ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ 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.

Appendix B

HydroCAD® Input/Output



Routing Diagram for 143-82806-13003_EC-WATERSHED
Prepared by Tetra Tech, Printed 3/28/2013

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.220	69	50-75% Grass cover, Fair, HSG B (2S)
0.190	98	Paved roads w/curbs & driveways (1S)
0.260	98	Paved roads w/curbs & sewers (2S)
6.240	55	Woods, Good, HSG B (1S)
0.630	77	Woods, Good, HSG D (1S)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Site Runoff Area=7.060 ac 2.69% Impervious Runoff Depth=0.34"
Flow Length=1,043' Tc=21.4 min CN=58 Runoff=1.03 cfs 0.201 af

Subcatchment 2S: Greendale Avenue Runoff Area=0.480 ac 54.17% Impervious Runoff Depth=1.76"
Flow Length=620' Tc=4.5 min CN=85 Runoff=1.04 cfs 0.070 af

Reach 1R: Low Point Inflow=1.03 cfs 0.201 af
Outflow=1.03 cfs 0.201 af

Reach 2R: Catch Basin Inflow=1.04 cfs 0.070 af
Outflow=1.04 cfs 0.070 af

Summary for Subcatchment 1S: Existing Site

Runoff = 1.03 cfs @ 12.49 hrs, Volume= 0.201 af, Depth= 0.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YEAR Rainfall=3.20"

	Area (ac)	CN	Description
*	0.190	98	Paved roads w/curbs & driveways
	6.240	55	Woods, Good, HSG B
	0.630	77	Woods, Good, HSG D
	7.060	58	Weighted Average
	6.870		97.31% Pervious Area
	0.190		2.69% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.4	324	0.1000	1.58		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
2.8	219	0.0680	1.30		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
15.2	500	0.0120	0.55		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
21.4	1,043	Total			

Summary for Subcatchment 2S: Greendale Avenue

Runoff = 1.04 cfs @ 12.07 hrs, Volume= 0.070 af, Depth= 1.76"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YEAR Rainfall=3.20"

	Area (ac)	CN	Description
*	0.260	98	Paved roads w/curbs & sewers
	0.220	69	50-75% Grass cover, Fair, HSG B
	0.480	85	Weighted Average
	0.220		45.83% Pervious Area
	0.260		54.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

Inflow Area = 7.060 ac, 2.69% Impervious, Inflow Depth = 0.34" for 2 YEAR event
Inflow = 1.03 cfs @ 12.49 hrs, Volume= 0.201 af
Outflow = 1.03 cfs @ 12.49 hrs, Volume= 0.201 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Reach 2R: Catch Basin

Inflow Area = 0.480 ac, 54.17% Impervious, Inflow Depth = 1.76" for 2 YEAR event
Inflow = 1.04 cfs @ 12.07 hrs, Volume= 0.070 af
Outflow = 1.04 cfs @ 12.07 hrs, Volume= 0.070 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Site Runoff Area=7.060 ac 2.69% Impervious Runoff Depth=1.01"
Flow Length=1,043' Tc=21.4 min CN=58 Runoff=4.54 cfs 0.593 af

Subcatchment 2S: Greendale Avenue Runoff Area=0.480 ac 54.17% Impervious Runoff Depth=3.09"
Flow Length=620' Tc=4.5 min CN=85 Runoff=1.82 cfs 0.124 af

Reach 1R: Low Point Inflow=4.54 cfs 0.593 af
Outflow=4.54 cfs 0.593 af

Reach 2R: Catch Basin Inflow=1.82 cfs 0.124 af
Outflow=1.82 cfs 0.124 af

Summary for Subcatchment 1S: Existing Site

Runoff = 4.54 cfs @ 12.35 hrs, Volume= 0.593 af, Depth= 1.01"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YEAR Rainfall=4.70"

	Area (ac)	CN	Description
*	0.190	98	Paved roads w/curbs & driveways
	6.240	55	Woods, Good, HSG B
	0.630	77	Woods, Good, HSG D
	7.060	58	Weighted Average
	6.870		97.31% Pervious Area
	0.190		2.69% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.4	324	0.1000	1.58		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
2.8	219	0.0680	1.30		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
15.2	500	0.0120	0.55		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
21.4	1,043	Total			

Summary for Subcatchment 2S: Greendale Avenue

Runoff = 1.82 cfs @ 12.07 hrs, Volume= 0.124 af, Depth= 3.09"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YEAR Rainfall=4.70"

	Area (ac)	CN	Description
*	0.260	98	Paved roads w/curbs & sewers
	0.220	69	50-75% Grass cover, Fair, HSG B
	0.480	85	Weighted Average
	0.220		45.83% Pervious Area
	0.260		54.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

Inflow Area = 7.060 ac, 2.69% Impervious, Inflow Depth = 1.01" for 10 YEAR event
Inflow = 4.54 cfs @ 12.35 hrs, Volume= 0.593 af
Outflow = 4.54 cfs @ 12.35 hrs, Volume= 0.593 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Reach 2R: Catch Basin

Inflow Area = 0.480 ac, 54.17% Impervious, Inflow Depth = 3.09" for 10 YEAR event
Inflow = 1.82 cfs @ 12.07 hrs, Volume= 0.124 af
Outflow = 1.82 cfs @ 12.07 hrs, Volume= 0.124 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Site Runoff Area=7.060 ac 2.69% Impervious Runoff Depth=1.45"
Flow Length=1,043' Tc=21.4 min CN=58 Runoff=7.06 cfs 0.855 af

Subcatchment 2S: Greendale Avenue Runoff Area=0.480 ac 54.17% Impervious Runoff Depth=3.83"
Flow Length=620' Tc=4.5 min CN=85 Runoff=2.24 cfs 0.153 af

Reach 1R: Low Point Inflow=7.06 cfs 0.855 af
Outflow=7.06 cfs 0.855 af

Reach 2R: Catch Basin Inflow=2.24 cfs 0.153 af
Outflow=2.24 cfs 0.153 af

Summary for Subcatchment 1S: Existing Site

Runoff = 7.06 cfs @ 12.34 hrs, Volume= 0.855 af, Depth= 1.45"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YEAR Rainfall=5.50"

	Area (ac)	CN	Description
*	0.190	98	Paved roads w/curbs & driveways
	6.240	55	Woods, Good, HSG B
	0.630	77	Woods, Good, HSG D
	7.060	58	Weighted Average
	6.870		97.31% Pervious Area
	0.190		2.69% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.4	324	0.1000	1.58		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
2.8	219	0.0680	1.30		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
15.2	500	0.0120	0.55		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
21.4	1,043	Total			

Summary for Subcatchment 2S: Greendale Avenue

Runoff = 2.24 cfs @ 12.07 hrs, Volume= 0.153 af, Depth= 3.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YEAR Rainfall=5.50"

	Area (ac)	CN	Description
*	0.260	98	Paved roads w/curbs & sewers
	0.220	69	50-75% Grass cover, Fair, HSG B
	0.480	85	Weighted Average
	0.220		45.83% Pervious Area
	0.260		54.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

Inflow Area = 7.060 ac, 2.69% Impervious, Inflow Depth = 1.45" for 25 YEAR event
Inflow = 7.06 cfs @ 12.34 hrs, Volume= 0.855 af
Outflow = 7.06 cfs @ 12.34 hrs, Volume= 0.855 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Reach 2R: Catch Basin

Inflow Area = 0.480 ac, 54.17% Impervious, Inflow Depth = 3.83" for 25 YEAR event
Inflow = 2.24 cfs @ 12.07 hrs, Volume= 0.153 af
Outflow = 2.24 cfs @ 12.07 hrs, Volume= 0.153 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Existing Site Runoff Area=7.060 ac 2.69% Impervious Runoff Depth=2.21"
Flow Length=1,043' Tc=21.4 min CN=58 Runoff=11.30 cfs 1.299 af

Subcatchment 2S: Greendale Avenue Runoff Area=0.480 ac 54.17% Impervious Runoff Depth=4.97"
Flow Length=620' Tc=4.5 min CN=85 Runoff=2.87 cfs 0.199 af

Reach 1R: Low Point Inflow=11.30 cfs 1.299 af
Outflow=11.30 cfs 1.299 af

Reach 2R: Catch Basin Inflow=2.87 cfs 0.199 af
Outflow=2.87 cfs 0.199 af

Summary for Subcatchment 1S: Existing Site

Runoff = 11.30 cfs @ 12.32 hrs, Volume= 1.299 af, Depth= 2.21"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YEAR Rainfall=6.70"

Area (ac)	CN	Description
* 0.190	98	Paved roads w/curbs & driveways
6.240	55	Woods, Good, HSG B
0.630	77	Woods, Good, HSG D
7.060	58	Weighted Average
6.870		97.31% Pervious Area
0.190		2.69% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.4	324	0.1000	1.58		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
2.8	219	0.0680	1.30		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
15.2	500	0.0120	0.55		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
21.4	1,043	Total			

Summary for Subcatchment 2S: Greendale Avenue

Runoff = 2.87 cfs @ 12.07 hrs, Volume= 0.199 af, Depth= 4.97"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YEAR Rainfall=6.70"

Area (ac)	CN	Description
* 0.260	98	Paved roads w/curbs & sewers
0.220	69	50-75% Grass cover, Fair, HSG B
0.480	85	Weighted Average
0.220		45.83% Pervious Area
0.260		54.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

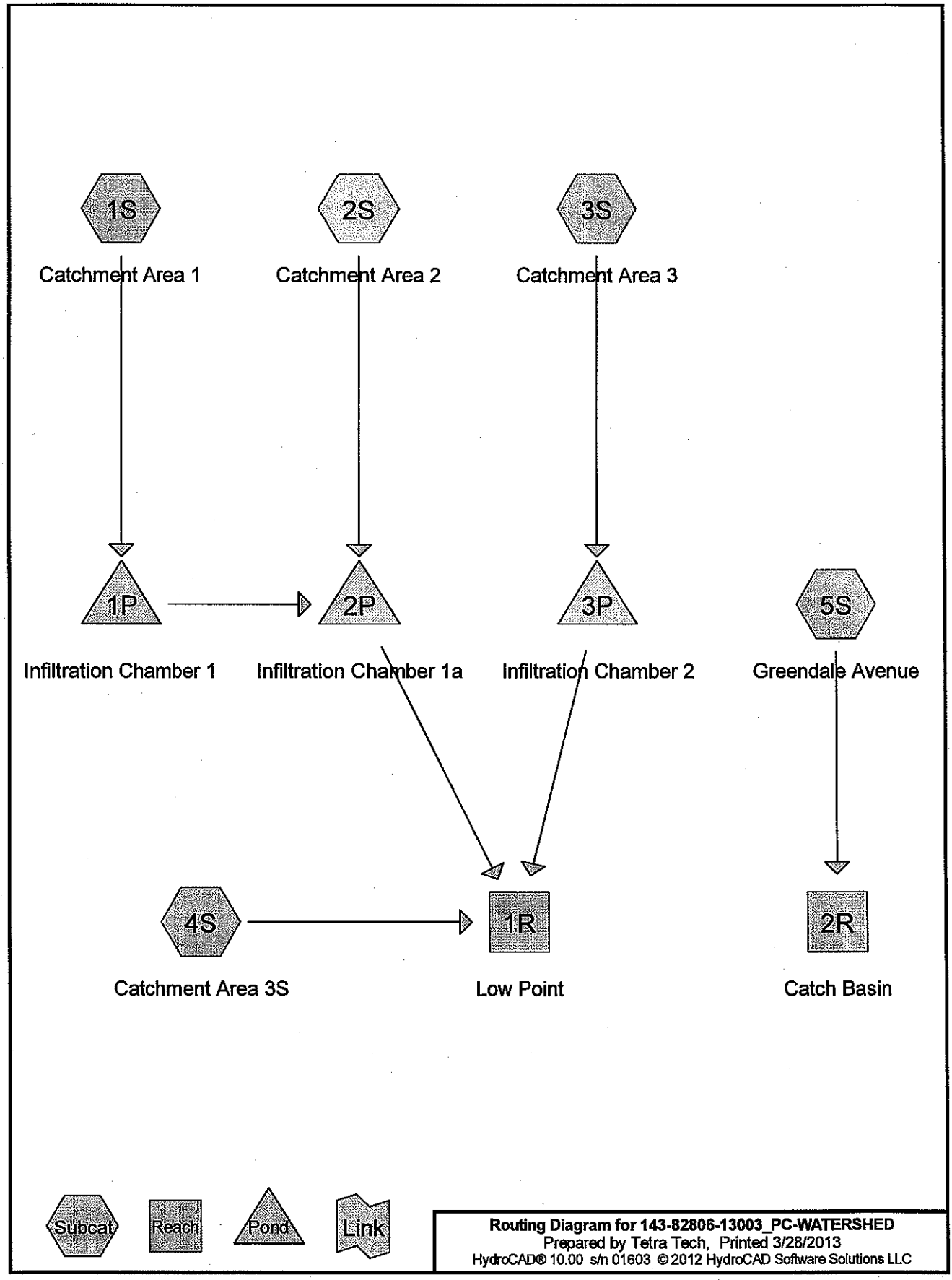
Inflow Area = 7.060 ac, 2.69% Impervious, Inflow Depth = 2.21" for 100 YEAR event
Inflow = 11.30 cfs @ 12.32 hrs, Volume= 1.299 af
Outflow = 11.30 cfs @ 12.32 hrs, Volume= 1.299 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Reach 2R: Catch Basin

Inflow Area = 0.480 ac, 54.17% Impervious, Inflow Depth = 4.97" for 100 YEAR event
Inflow = 2.87 cfs @ 12.07 hrs, Volume= 0.199 af
Outflow = 2.87 cfs @ 12.07 hrs, Volume= 0.199 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs


1S
Catchment Area 1
2S
Catchment Area 2
3S
Catchment Area 3
1P
Infiltration Chamber 1
2P
Infiltration Chamber 1a
3P
Infiltration Chamber 2
5S
Greendale Avenue
4S
Catchment Area 3S
1R
Low Point
2R
Catch Basin
Subcat
Reach
Pond
Link
Routing Diagram for 143-82806-13003_PC-WATERSHED
Prepared by Tetra Tech, Printed 3/28/2013
HydroCAD® 10.00 s/n 01603 © 2012 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.190	69	50-75% Grass cover, Fair, HSG B (5S)
1.590	61	>75% Grass cover, Good, HSG B (1S, 2S, 3S)
0.790	98	Impervious Landscaping (1S, 2S, 3S)
1.430	98	Pavement (1S, 2S, 3S, 5S)
1.870	98	Roof (1S, 2S, 3S)
1.100	55	Woods, Good, HSG B (4S)
0.570	77	Woods, Good, HSG D (4S)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Catchment Area 1 Runoff Area=1.090 ac 63.30% Impervious Runoff Depth=1.68"
Tc=5.0 min CN=84 Runoff=2.23 cfs 0.153 af

Subcatchment 2S: Catchment Area 2 Runoff Area=2.030 ac 75.86% Impervious Runoff Depth=2.08"
Tc=5.0 min CN=89 Runoff=5.10 cfs 0.352 af

Subcatchment 3S: Catchment Area 3 Runoff Area=2.290 ac 69.43% Impervious Runoff Depth=1.91"
Tc=5.0 min CN=87 Runoff=5.32 cfs 0.365 af

Subcatchment 4S: Catchment Area 3S Runoff Area=1.670 ac 0.00% Impervious Runoff Depth=0.52"
Flow Length=1,041' Tc=18.2 min CN=63 Runoff=0.51 cfs 0.072 af

Subcatchment 5S: Greendale Avenue Runoff Area=0.460 ac 58.70% Impervious Runoff Depth=1.84"
Flow Length=620' Tc=4.5 min CN=86 Runoff=1.04 cfs 0.070 af

Reach 1R: Low Point Inflow=1.03 cfs 0.117 af
Outflow=1.03 cfs 0.117 af

Reach 2R: Catch Basin Inflow=1.04 cfs 0.070 af
Outflow=1.04 cfs 0.070 af

Pond 1P: Infiltration Chamber 1 Peak Elev=135.83' Storage=1,758 cf Inflow=2.23 cfs 0.153 af
Discarded=0.42 cfs 0.153 af Primary=0.00 cfs 0.000 af Outflow=0.42 cfs 0.153 af

Pond 2P: Infiltration Chamber 1a Peak Elev=131.20' Storage=4,283 cf Inflow=5.10 cfs 0.352 af
Discarded=0.78 cfs 0.329 af Primary=0.25 cfs 0.023 af Outflow=1.03 cfs 0.352 af

Pond 3P: Infiltration Chamber 2 Peak Elev=113.03' Storage=4,268 cf Inflow=5.32 cfs 0.365 af
Discarded=0.87 cfs 0.344 af Primary=0.30 cfs 0.021 af Outflow=1.17 cfs 0.365 af

Summary for Subcatchment 1S: Catchment Area 1

Runoff = 2.23 cfs @ 12.08 hrs, Volume= 0.153 af, Depth= 1.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YEAR Rainfall=3.20"

	Area (ac)	CN	Description
*	0.430	98	Roof
*	0.080	98	Pavement
*	0.180	98	Impervious Landscaping
	0.400	61	>75% Grass cover, Good, HSG B
	1.090	84	Weighted Average
	0.400		36.70% Pervious Area
	0.690		63.30% Impervious Area

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

Summary for Subcatchment 2S: Catchment Area 2

Runoff = 5.10 cfs @ 12.07 hrs, Volume= 0.352 af, Depth= 2.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YEAR Rainfall=3.20"

	Area (ac)	CN	Description
*	0.570	98	Pavement
*	0.680	98	Roof
*	0.290	98	Impervious Landscaping
	0.490	61	>75% Grass cover, Good, HSG B
	2.030	89	Weighted Average
	0.490		24.14% Pervious Area
	1.540		75.86% Impervious Area

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

Summary for Subcatchment 3S: Catchment Area 3

Runoff = 5.32 cfs @ 12.07 hrs, Volume= 0.365 af, Depth= 1.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YEAR Rainfall=3.20"

	Area (ac)	CN	Description
*	0.320	98	Impervious Landscaping
	0.700	61	>75% Grass cover, Good, HSG B
*	0.510	98	Pavement
*	0.760	98	Roof
	2.290	87	Weighted Average
	0.700		30.57% Pervious Area
	1.590		69.43% Impervious Area

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

Summary for Subcatchment 4S: Catchment Area 3S

Runoff = 0.51 cfs @ 12.32 hrs, Volume= 0.072 af, Depth= 0.52"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YEAR Rainfall=3.20"

Area (ac)	CN	Description
0.570	77	Woods, Good, HSG D
1.100	55	Woods, Good, HSG B
1.670	63	Weighted Average
1.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	330	0.0900	1.50		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
4.0	190	0.0250	0.79		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.0	300	0.0400	1.00		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.5	221	0.0180	0.67		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
18.2	1,041	Total			

Summary for Subcatchment 5S: Greendale Avenue

Runoff = 1.04 cfs @ 12.07 hrs, Volume= 0.070 af, Depth= 1.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2 YEAR Rainfall=3.20"

	Area (ac)	CN	Description
*	0.270	98	Pavement
	0.190	69	50-75% Grass cover, Fair, HSG B
	0.460	86	Weighted Average
	0.190		41.30% Pervious Area
	0.270		58.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

Inflow Area = 7.080 ac, 53.95% Impervious, Inflow Depth = 0.20" for 2 YEAR event
Inflow = 1.03 cfs @ 12.39 hrs, Volume= 0.117 af
Outflow = 1.03 cfs @ 12.39 hrs, Volume= 0.117 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Reach 2R: Catch Basin

Inflow Area = 0.460 ac, 58.70% Impervious, Inflow Depth = 1.84" for 2 YEAR event
Inflow = 1.04 cfs @ 12.07 hrs, Volume= 0.070 af
Outflow = 1.04 cfs @ 12.07 hrs, Volume= 0.070 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Pond 1P: Infiltration Chamber 1

Inflow Area = 1.090 ac, 63.30% Impervious, Inflow Depth = 1.68" for 2 YEAR event
Inflow = 2.23 cfs @ 12.08 hrs, Volume= 0.153 af
Outflow = 0.42 cfs @ 12.53 hrs, Volume= 0.153 af, Atten= 81%, Lag= 27.2 min
Discarded = 0.42 cfs @ 12.53 hrs, Volume= 0.153 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 135.83' @ 12.53 hrs Surf.Area= 1,914 sf Storage= 1,758 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 25.9 min (854.6 - 828.6)

Volume	Invert	Avail.Storage	Storage Description
#1	134.50'	2,770 cf	**22.00'W x 87.00'L x 6.00'H Crushed Stone** 11,484 cf Overall - 4,558 cf Embedded = 6,926 cf x 40.0% Voids
#2	135.00'	4,558 cf	**Cultec R-900HD** x 36 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		7,328 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	138.00'	**12.0" Round Pipe** L= 30.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 138.00' / 133.00' S= 0.1667 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 0.79 sf
#2	Discarded	134.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.42 cfs @ 12.53 hrs HW=135.83' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.42 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=134.50' TW=129.50' (Dynamic Tailwater)
↑—**1=Pipe** (Controls 0.00 cfs)

Summary for Pond 2P: Infiltration Chamber 1a

Inflow Area = 3.120 ac, 71.47% Impervious, Inflow Depth = 1.35" for 2 YEAR event
Inflow = 5.10 cfs @ 12.07 hrs, Volume= 0.352 af
Outflow = 1.03 cfs @ 12.50 hrs, Volume= 0.352 af, Atten= 80%, Lag= 25.7 min
Discarded = 0.78 cfs @ 12.50 hrs, Volume= 0.329 af
Primary = 0.25 cfs @ 12.50 hrs, Volume= 0.023 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 131.20' @ 12.50 hrs Surf.Area= 3,454 sf Storage= 4,283 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 30.1 min (840.2 - 810.2)

Volume	Invert	Avail.Storage	Storage Description
#1	129.50'	4,987 cf	**22.00'W x 157.00'L x 6.00'H Crushed Stone** 20,724 cf Overall - 8,257 cf Embedded = 12,467 cf x 40.0% Voids
#2	130.00'	8,257 cf	**Cultec R-900HD** x 66 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		13,244 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	130.50'	**15.0" Round Pipe** L= 230.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 130.50' / 110.42' S= 0.0873 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	130.50'	**2.5" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	135.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir**

			Head (feet) 0.20 0.40 0.60 0.80 1.00
			Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	129.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.78 cfs @ 12.50 hrs HW=131.20' (Free Discharge)
└**4=Exfiltration** (Exfiltration Controls 0.78 cfs)

Primary OutFlow Max=0.25 cfs @ 12.50 hrs HW=131.20' TW=0.00' (Dynamic Tailwater)
└**1=Pipe** (Passes 0.25 cfs of 2.77 cfs potential flow)
  ├**2=Orifice #1** (Orifice Controls 0.25 cfs @ 3.73 fps)
  └**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 3P: Infiltration Chamber 2

Inflow Area = 2.290 ac, 69.43% Impervious, Inflow Depth = 1.91" for 2 YEAR event
Inflow = 5.32 cfs @ 12.07 hrs, Volume= 0.365 af
Outflow = 1.17 cfs @ 12.49 hrs, Volume= 0.365 af, Atten= 78%, Lag= 25.0 min
Discarded = 0.87 cfs @ 12.49 hrs, Volume= 0.344 af
Primary = 0.30 cfs @ 12.49 hrs, Volume= 0.021 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 113.03' @ 12.49 hrs Surf.Area= 3,916 sf Storage= 4,268 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 26.9 min (844.8 - 817.9)

Volume	Invert	Avail.Storage	Storage Description
#1	111.50'	5,652 cf	**22.00'W x 178.00'L x 6.00'H Crushed Stone** 23,496 cf Overall - 9,367 cf Embedded = 14,129 cf x 40.0% Voids
#2	112.00'	9,367 cf	**Cultec R-900HD** x 75 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		15,018 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	112.50'	**15.0" Round Pipe** L= 43.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 112.50' / 110.25' S= 0.0523 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	112.50'	**3.0" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	116.50'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	111.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.87 cfs @ 12.49 hrs HW=113.03' (Free Discharge)
└**4=Exfiltration** (Exfiltration Controls 0.87 cfs)

Primary OutFlow Max=0.30 cfs @ 12.49 hrs HW=113.03' TW=0.00' (Dynamic Tailwater)
└**1=Pipe** (Passes 0.30 cfs of 1.21 cfs potential flow)
  ├**2=Orifice #1** (Orifice Controls 0.30 cfs @ 3.05 fps)
  └**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Catchment Area 1 Runoff Area=1.090 ac 63.30% Impervious Runoff Depth=3.00"
Tc=5.0 min CN=84 Runoff=3.95 cfs 0.272 af

Subcatchment 2S: Catchment Area 2 Runoff Area=2.030 ac 75.86% Impervious Runoff Depth=3.49"
Tc=5.0 min CN=89 Runoff=8.38 cfs 0.590 af

Subcatchment 3S: Catchment Area 3 Runoff Area=2.290 ac 69.43% Impervious Runoff Depth=3.29"
Tc=5.0 min CN=87 Runoff=9.01 cfs 0.627 af

Subcatchment 4S: Catchment Area 3S Runoff Area=1.670 ac 0.00% Impervious Runoff Depth=1.32"
Flow Length=1,041' Tc=18.2 min CN=63 Runoff=1.65 cfs 0.184 af

Subcatchment 5S: Greendale Avenue Runoff Area=0.460 ac 58.70% Impervious Runoff Depth=3.19"
Flow Length=620' Tc=4.5 min CN=86 Runoff=1.79 cfs 0.122 af

Reach 1R: Low Point Inflow=2.65 cfs 0.375 af
Outflow=2.65 cfs 0.375 af

Reach 2R: Catch Basin Inflow=1.79 cfs 0.122 af
Outflow=1.79 cfs 0.122 af

Pond 1P: Infiltration Chamber 1 Peak Elev=137.28' Storage=4,052 cf Inflow=3.95 cfs 0.272 af
Discarded=0.48 cfs 0.272 af Primary=0.00 cfs 0.000 af Outflow=0.48 cfs 0.272 af

Pond 2P: Infiltration Chamber 1a Peak Elev=132.68' Storage=8,355 cf Inflow=8.38 cfs 0.590 af
Discarded=0.88 cfs 0.500 af Primary=0.47 cfs 0.089 af Outflow=1.35 cfs 0.590 af

Pond 3P: Infiltration Chamber 2 Peak Elev=114.39' Storage=8,617 cf Inflow=9.01 cfs 0.627 af
Discarded=0.97 cfs 0.525 af Primary=0.63 cfs 0.102 af Outflow=1.60 cfs 0.627 af

Summary for Subcatchment 1S: Catchment Area 1

Runoff = 3.95 cfs @ 12.07 hrs, Volume= 0.272 af, Depth= 3.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YEAR Rainfall=4.70"

	Area (ac)	CN	Description
*	0.430	98	Roof
*	0.080	98	Pavement
*	0.180	98	Impervious Landscaping
	0.400	61	>75% Grass cover, Good, HSG B
	1.090	84	Weighted Average
	0.400		36.70% Pervious Area
	0.690		63.30% Impervious Area

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

Summary for Subcatchment 2S: Catchment Area 2

Runoff = 8.38 cfs @ 12.07 hrs, Volume= 0.590 af, Depth= 3.49"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YEAR Rainfall=4.70"

	Area (ac)	CN	Description
*	0.570	98	Pavement
*	0.680	98	Roof
*	0.290	98	Impervious Landscaping
	0.490	61	>75% Grass cover, Good, HSG B
	2.030	89	Weighted Average
	0.490		24.14% Pervious Area
	1.540		75.86% Impervious Area

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

Summary for Subcatchment 3S: Catchment Area 3

Runoff = 9.01 cfs @ 12.07 hrs, Volume= 0.627 af, Depth= 3.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YEAR Rainfall=4.70"

	Area (ac)	CN	Description
*	0.320	98	Impervious Landscaping
	0.700	61	>75% Grass cover, Good, HSG B
*	0.510	98	Pavement
*	0.760	98	Roof
	2.290	87	Weighted Average
	0.700		30.57% Pervious Area
	1.590		69.43% Impervious Area

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

Summary for Subcatchment 4S: Catchment Area 3S

Runoff = 1.65 cfs @ 12.28 hrs, Volume= 0.184 af, Depth= 1.32"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YEAR Rainfall=4.70"

Area (ac)	CN	Description
0.570	77	Woods, Good, HSG D
1.100	55	Woods, Good, HSG B
1.670	63	Weighted Average
1.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	330	0.0900	1.50		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
4.0	190	0.0250	0.79		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.0	300	0.0400	1.00		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.5	221	0.0180	0.67		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
18.2	1,041	Total			

Summary for Subcatchment 5S: Greendale Avenue

Runoff = 1.79 cfs @ 12.07 hrs, Volume= 0.122 af, Depth= 3.19"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10 YEAR Rainfall=4.70"

	Area (ac)	CN	Description
*	0.270	98	Pavement
	0.190	69	50-75% Grass cover, Fair, HSG B
	0.460	86	Weighted Average
	0.190		41.30% Pervious Area
	0.270		58.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

Inflow Area = 7.080 ac, 53.95% Impervious, Inflow Depth = 0.64" for 10 YEAR event
Inflow = 2.65 cfs @ 12.29 hrs, Volume= 0.375 af
Outflow = 2.65 cfs @ 12.29 hrs, Volume= 0.375 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Reach 2R: Catch Basin

Inflow Area = 0.460 ac, 58.70% Impervious, Inflow Depth = 3.19" for 10 YEAR event
Inflow = 1.79 cfs @ 12.07 hrs, Volume= 0.122 af
Outflow = 1.79 cfs @ 12.07 hrs, Volume= 0.122 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Pond 1P: Infiltration Chamber 1

Inflow Area = 1.090 ac, 63.30% Impervious, Inflow Depth = 3.00" for 10 YEAR event
Inflow = 3.95 cfs @ 12.07 hrs, Volume= 0.272 af
Outflow = 0.48 cfs @ 12.68 hrs, Volume= 0.272 af, Atten= 88%, Lag= 36.2 min
Discarded = 0.48 cfs @ 12.68 hrs, Volume= 0.272 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 137.28' @ 12.68 hrs Surf.Area= 1,914 sf Storage= 4,052 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 65.9 min (878.0 - 812.1)

Volume	Invert	Avail.Storage	Storage Description
#1	134.50'	2,770 cf	**22.00'W x 87.00'L x 6.00'H Crushed Stone** 11,484 cf Overall - 4,558 cf Embedded = 6,926 cf x 40.0% Voids
#2	135.00'	4,558 cf	**Cultec R-900HD** x 36 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		7,328 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	138.00'	**12.0" Round Pipe** L= 30.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 138.00' / 133.00' S= 0.1667 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 0.79 sf
#2	Discarded	134.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.48 cfs @ 12.68 hrs HW=137.28' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.48 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=134.50' TW=129.50' (Dynamic Tailwater)
↑—**1=Pipe** (Controls 0.00 cfs)

Summary for Pond 2P: Infiltration Chamber 1a

Inflow Area = 3.120 ac, 71.47% Impervious, Inflow Depth = 2.27" for 10 YEAR event
Inflow = 8.38 cfs @ 12.07 hrs, Volume= 0.590 af
Outflow = 1.35 cfs @ 12.54 hrs, Volume= 0.590 af, Atten= 84%, Lag= 28.0 min
Discarded = 0.88 cfs @ 12.54 hrs, Volume= 0.500 af
Primary = 0.47 cfs @ 12.54 hrs, Volume= 0.089 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 132.68' @ 12.54 hrs Surf.Area= 3,454 sf Storage= 8,355 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 49.7 min (845.4 - 795.7)

Volume	Invert	Avail.Storage	Storage Description
#1	129.50'	4,987 cf	**22.00'W x 157.00'L x 6.00'H Crushed Stone** 20,724 cf Overall - 8,257 cf Embedded = 12,467 cf x 40.0% Voids
#2	130.00'	8,257 cf	**Cultec R-900HD** x 66 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		13,244 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	130.50'	**15.0" Round Pipe** L= 230.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 130.50' / 110.42' S= 0.0873 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	130.50'	**2.5" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	135.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir**

			Head (feet) 0.20 0.40 0.60 0.80 1.00
			Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	129.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.88 cfs @ 12.54 hrs HW=132.68' (Free Discharge)
↑**4=Exfiltration** (Exfiltration Controls 0.88 cfs)

Primary OutFlow Max=0.47 cfs @ 12.54 hrs HW=132.68' TW=0.00' (Dynamic Tailwater)
↑**1=Pipe** (Passes 0.47 cfs of 10.04 cfs potential flow)
↑**2=Orifice #1** (Orifice Controls 0.47 cfs @ 6.93 fps)
3=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 3P: Infiltration Chamber 2

Inflow Area = 2.290 ac, 69.43% Impervious, Inflow Depth = 3.29" for 10 YEAR event
Inflow = 9.01 cfs @ 12.07 hrs, Volume= 0.627 af
Outflow = 1.60 cfs @ 12.52 hrs, Volume= 0.627 af, Atten= 82%, Lag= 27.1 min
Discarded = 0.97 cfs @ 12.52 hrs, Volume= 0.525 af
Primary = 0.63 cfs @ 12.52 hrs, Volume= 0.102 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 114.39' @ 12.52 hrs Surf.Area= 3,916 sf Storage= 8,617 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 44.0 min (846.6 - 802.6)

Volume	Invert	Avail.Storage	Storage Description
#1	111.50'	5,652 cf	**22.00'W x 178.00'L x 6.00'H Crushed Stone** 23,496 cf Overall - 9,367 cf Embedded = 14,129 cf x 40.0% Voids
#2	112.00'	9,367 cf	**Cultec R-900HD** x 75 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		15,018 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	112.50'	**15.0" Round Pipe** L= 43.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 112.50' / 110.25' S= 0.0523 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	112.50'	**3.0" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	116.50'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	111.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.97 cfs @ 12.52 hrs HW=114.39' (Free Discharge)
↑—**4=Exfiltration** (Exfiltration Controls 0.97 cfs)

Primary OutFlow Max=0.63 cfs @ 12.52 hrs HW=114.39' TW=0.00' (Dynamic Tailwater)
↑—**1=Pipe** (Passes 0.63 cfs of 6.63 cfs potential flow)
  ↑—**2=Orifice #1** (Orifice Controls 0.63 cfs @ 6.39 fps)
  └—**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Catchment Area 1 Runoff Area=1.090 ac 63.30% Impervious Runoff Depth=3.73"
Tc=5.0 min CN=84 Runoff=4.89 cfs 0.339 af

Subcatchment 2S: Catchment Area 2 Runoff Area=2.030 ac 75.86% Impervious Runoff Depth=4.25"
Tc=5.0 min CN=89 Runoff=10.12 cfs 0.719 af

Subcatchment 3S: Catchment Area 3 Runoff Area=2.290 ac 69.43% Impervious Runoff Depth=4.04"
Tc=5.0 min CN=87 Runoff=10.98 cfs 0.771 af

Subcatchment 4S: Catchment Area 3S Runoff Area=1.670 ac 0.00% Impervious Runoff Depth=1.83"
Flow Length=1,041' Tc=18.2 min CN=63 Runoff=2.38 cfs 0.255 af

Subcatchment 5S: Greendale Avenue Runoff Area=0.460 ac 58.70% Impervious Runoff Depth=3.94"
Flow Length=620' Tc=4.5 min CN=86 Runoff=2.20 cfs 0.151 af

Reach 1R: Low Point Inflow=3.60 cfs 0.544 af
Outflow=3.60 cfs 0.544 af

Reach 2R: Catch Basin Inflow=2.20 cfs 0.151 af
Outflow=2.20 cfs 0.151 af

Pond 1P: Infiltration Chamber 1 Peak Elev=138.17' Storage=5,287 cf Inflow=4.89 cfs 0.339 af
Discarded=0.52 cfs 0.334 af Primary=0.17 cfs 0.005 af Outflow=0.69 cfs 0.339 af

Pond 2P: Infiltration Chamber 1a Peak Elev=133.73' Storage=10,737 cf Inflow=10.12 cfs 0.724 af
Discarded=0.95 cfs 0.590 af Primary=0.58 cfs 0.134 af Outflow=1.53 cfs 0.724 af

Pond 3P: Infiltration Chamber 2 Peak Elev=115.29' Storage=11,156 cf Inflow=10.98 cfs 0.771 af
Discarded=1.04 cfs 0.617 af Primary=0.77 cfs 0.154 af Outflow=1.81 cfs 0.771 af

Summary for Subcatchment 1S: Catchment Area 1

Runoff = 4.89 cfs @ 12.07 hrs, Volume= 0.339 af, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YEAR Rainfall=5.50"

	Area (ac)	CN	Description
*	0.430	98	Roof
*	0.080	98	Pavement
*	0.180	98	Impervious Landscaping
	0.400	61	>75% Grass cover, Good, HSG B
	1.090	84	Weighted Average
	0.400		36.70% Pervious Area
	0.690		63.30% Impervious Area

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

Summary for Subcatchment 2S: Catchment Area 2

Runoff = 10.12 cfs @ 12.07 hrs, Volume= 0.719 af, Depth= 4.25"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YEAR Rainfall=5.50"

	Area (ac)	CN	Description
*	0.570	98	Pavement
*	0.680	98	Roof
*	0.290	98	Impervious Landscaping
	0.490	61	>75% Grass cover, Good, HSG B
	2.030	89	Weighted Average
	0.490		24.14% Pervious Area
	1.540		75.86% Impervious Area

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

Summary for Subcatchment 3S: Catchment Area 3

Runoff = 10.98 cfs @ 12.07 hrs, Volume= 0.771 af, Depth= 4.04"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YEAR Rainfall=5.50"

	Area (ac)	CN	Description
*	0.320	98	Impervious Landscaping
	0.700	61	>75% Grass cover, Good, HSG B
*	0.510	98	Pavement
*	0.760	98	Roof
	2.290	87	Weighted Average
	0.700		30.57% Pervious Area
	1.590		69.43% Impervious Area

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

Summary for Subcatchment 4S: Catchment Area 3S

Runoff = 2.38 cfs @ 12.27 hrs, Volume= 0.255 af, Depth= 1.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YEAR Rainfall=5.50"

Area (ac)	CN	Description
0.570	77	Woods, Good, HSG D
1.100	55	Woods, Good, HSG B
1.670	63	Weighted Average
1.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	330	0.0900	1.50		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
4.0	190	0.0250	0.79		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.0	300	0.0400	1.00		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.5	221	0.0180	0.67		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
18.2	1,041	Total			

Summary for Subcatchment 5S: Greendale Avenue

Runoff = 2.20 cfs @ 12.07 hrs, Volume= 0.151 af, Depth= 3.94"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25 YEAR Rainfall=5.50"

	Area (ac)	CN	Description
*	0.270	98	Pavement
	0.190	69	50-75% Grass cover, Fair, HSG B
	0.460	86	Weighted Average
	0.190		41.30% Pervious Area
	0.270		58.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

Inflow Area = 7.080 ac, 53.95% Impervious, Inflow Depth = 0.92" for 25 YEAR event
Inflow = 3.60 cfs @ 12.28 hrs, Volume= 0.544 af
Outflow = 3.60 cfs @ 12.28 hrs, Volume= 0.544 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Reach 2R: Catch Basin

Inflow Area = 0.460 ac, 58.70% Impervious, Inflow Depth = 3.94" for 25 YEAR event
Inflow = 2.20 cfs @ 12.07 hrs, Volume= 0.151 af
Outflow = 2.20 cfs @ 12.07 hrs, Volume= 0.151 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Pond 1P: Infiltration Chamber 1

Inflow Area = 1.090 ac, 63.30% Impervious, Inflow Depth = 3.73" for 25 YEAR event
Inflow = 4.89 cfs @ 12.07 hrs, Volume= 0.339 af
Outflow = 0.69 cfs @ 12.58 hrs, Volume= 0.339 af, Atten= 86%, Lag= 30.3 min
Discarded = 0.52 cfs @ 12.58 hrs, Volume= 0.334 af
Primary = 0.17 cfs @ 12.58 hrs, Volume= 0.005 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 138.17' @ 12.58 hrs Surf.Area= 1,914 sf Storage= 5,287 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 82.6 min (888.5 - 805.9)

Volume	Invert	Avail.Storage	Storage Description
#1	134.50'	2,770 cf	**22.00'W x 87.00'L x 6.00'H Crushed Stone** 11,484 cf Overall - 4,558 cf Embedded = 6,926 cf x 40.0% Voids
#2	135.00'	4,558 cf	**Cultec R-900HD** x 36 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		7,328 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	138.00'	**12.0" Round Pipe** L= 30.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 138.00' / 133.00' S= 0.1667 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 0.79 sf
#2	Discarded	134.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.52 cfs @ 12.58 hrs HW=138.17' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.52 cfs)

Primary OutFlow Max=0.17 cfs @ 12.58 hrs HW=138.17' TW=133.73' (Dynamic Tailwater)
↑—**1=Pipe** (Inlet Controls 0.17 cfs @ 1.91 fps)

Summary for Pond 2P: Infiltration Chamber 1a

Inflow Area = 3.120 ac, 71.47% Impervious, Inflow Depth = 2.79" for 25 YEAR event
Inflow = 10.12 cfs @ 12.07 hrs, Volume= 0.724 af
Outflow = 1.53 cfs @ 12.58 hrs, Volume= 0.724 af, Atten= 85%, Lag= 30.5 min
Discarded = 0.95 cfs @ 12.58 hrs, Volume= 0.590 af
Primary = 0.58 cfs @ 12.58 hrs, Volume= 0.134 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 133.73' @ 12.58 hrs Surf.Area= 3,454 sf Storage= 10,737 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 59.7 min (849.7 - 790.0)

Volume	Invert	Avail.Storage	Storage Description
#1	129.50'	4,987 cf	**22.00'W x 157.00'L x 6.00'H Crushed Stone** 20,724 cf Overall - 8,257 cf Embedded = 12,467 cf x 40.0% Voids
#2	130.00'	8,257 cf	**Cultec R-900HD** x 66 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		13,244 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	130.50'	**15.0" Round Pipe** L= 230.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 130.50' / 110.42' S= 0.0873 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	130.50'	**2.5" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	135.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir**

			Head (feet) 0.20 0.40 0.60 0.80 1.00
			Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	129.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.95 cfs @ 12.58 hrs HW=133.73' (Free Discharge)
└**4=Exfiltration** (Exfiltration Controls 0.95 cfs)

Primary OutFlow Max=0.58 cfs @ 12.58 hrs HW=133.73' TW=0.00' (Dynamic Tailwater)
└**1=Pipe** (Passes 0.58 cfs of 13.01 cfs potential flow)
  ├**2=Orifice #1** (Orifice Controls 0.58 cfs @ 8.51 fps)
  └**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 3P: Infiltration Chamber 2

Inflow Area = 2.290 ac, 69.43% Impervious, Inflow Depth = 4.04" for 25 YEAR event
Inflow = 10.98 cfs @ 12.07 hrs, Volume= 0.771 af
Outflow = 1.81 cfs @ 12.54 hrs, Volume= 0.771 af, Atten= 83%, Lag= 27.8 min
Discarded = 1.04 cfs @ 12.54 hrs, Volume= 0.617 af
Primary = 0.77 cfs @ 12.54 hrs, Volume= 0.154 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 115.29' @ 12.54 hrs Surf.Area= 3,916 sf Storage= 11,156 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 52.2 min (849.1 - 796.8)

Volume	Invert	Avail.Storage	Storage Description
#1	111.50'	5,652 cf	**22.00'W x 178.00'L x 6.00'H Crushed Stone** 23,496 cf Overall - 9,367 cf Embedded = 14,129 cf x 40.0% Voids
#2	112.00'	9,367 cf	**Cultec R-900HD** x 75 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		15,018 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	112.50'	**15.0" Round Pipe** L= 43.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 112.50' / 110.25' S= 0.0523 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	112.50'	**3.0" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	116.50'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	111.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=1.04 cfs @ 12.54 hrs HW=115.29' (Free Discharge)
↑—**4=Exfiltration** (Exfiltration Controls 1.04 cfs)

Primary OutFlow Max=0.77 cfs @ 12.54 hrs HW=115.29' TW=0.00' (Dynamic Tailwater)
↑—**1=Pipe** (Passes 0.77 cfs of 8.70 cfs potential flow)
↑—**2=Orifice #1** (Orifice Controls 0.77 cfs @ 7.86 fps)
└—**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points x 3
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Catchment Area 1 Runoff Area=1.090 ac 63.30% Impervious Runoff Depth=4.86"
Tc=5.0 min CN=84 Runoff=6.30 cfs 0.441 af

Subcatchment 2S: Catchment Area 2 Runoff Area=2.030 ac 75.86% Impervious Runoff Depth=5.42"
Tc=5.0 min CN=89 Runoff=12.73 cfs 0.916 af

Subcatchment 3S: Catchment Area 3 Runoff Area=2.290 ac 69.43% Impervious Runoff Depth=5.19"
Tc=5.0 min CN=87 Runoff=13.93 cfs 0.990 af

Subcatchment 4S: Catchment Area 3S Runoff Area=1.670 ac 0.00% Impervious Runoff Depth=2.68"
Flow Length=1,041' Tc=18.2 min CN=63 Runoff=3.58 cfs 0.373 af

Subcatchment 5S: Greendale Avenue Runoff Area=0.460 ac 58.70% Impervious Runoff Depth=5.08"
Flow Length=620' Tc=4.5 min CN=86 Runoff=2.80 cfs 0.195 af

Reach 1R: Low Point Inflow=11.08 cfs 0.899 af
Outflow=11.08 cfs 0.899 af

Reach 2R: Catch Basin Inflow=2.80 cfs 0.195 af
Outflow=2.80 cfs 0.195 af

Pond 1P: Infiltration Chamber 1 Peak Elev=138.61' Storage=5,807 cf Inflow=6.30 cfs 0.441 af
Discarded=0.54 cfs 0.384 af Primary=1.80 cfs 0.057 af Outflow=2.33 cfs 0.441 af

Pond 2P: Infiltration Chamber 1a Peak Elev=135.50' Storage=13,237 cf Inflow=12.73 cfs 0.973 af
Discarded=1.07 cfs 0.702 af Primary=4.90 cfs 0.272 af Outflow=5.98 cfs 0.973 af

Pond 3P: Infiltration Chamber 2 Peak Elev=116.82' Storage=13,957 cf Inflow=13.93 cfs 0.990 af
Discarded=1.16 cfs 0.735 af Primary=3.07 cfs 0.255 af Outflow=4.23 cfs 0.990 af

Summary for Subcatchment 1S: Catchment Area 1

Runoff = 6.30 cfs @ 12.07 hrs, Volume= 0.441 af, Depth= 4.86"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YEAR Rainfall=6.70"

	Area (ac)	CN	Description
*	0.430	98	Roof
*	0.080	98	Pavement
*	0.180	98	Impervious Landscaping
	0.400	61	>75% Grass cover, Good, HSG B
	1.090	84	Weighted Average
	0.400		36.70% Pervious Area
	0.690		63.30% Impervious Area

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

Summary for Subcatchment 2S: Catchment Area 2

Runoff = 12.73 cfs @ 12.07 hrs, Volume= 0.916 af, Depth= 5.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YEAR Rainfall=6.70"

	Area (ac)	CN	Description
*	0.570	98	Pavement
*	0.680	98	Roof
*	0.290	98	Impervious Landscaping
	0.490	61	>75% Grass cover, Good, HSG B
	2.030	89	Weighted Average
	0.490		24.14% Pervious Area
	1.540		75.86% Impervious Area

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

Summary for Subcatchment 3S: Catchment Area 3

Runoff = 13.93 cfs @ 12.07 hrs, Volume= 0.990 af, Depth= 5.19"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YEAR Rainfall=6.70"

	Area (ac)	CN	Description
*	0.320	98	Impervious Landscaping
	0.700	61	>75% Grass cover, Good, HSG B
*	0.510	98	Pavement
*	0.760	98	Roof
	2.290	87	Weighted Average
	0.700		30.57% Pervious Area
	1.590		69.43% Impervious Area

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

Summary for Subcatchment 4S: Catchment Area 3S

Runoff = 3.58 cfs @ 12.27 hrs, Volume= 0.373 af, Depth= 2.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YEAR Rainfall=6.70"

Area (ac)	CN	Description
0.570	77	Woods, Good, HSG D
1.100	55	Woods, Good, HSG B
1.670	63	Weighted Average
1.670		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.7	330	0.0900	1.50		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
4.0	190	0.0250	0.79		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.0	300	0.0400	1.00		**Shallow Concentrated Flow, Low Side of Retaining Wall** Woodland Kv= 5.0 fps
5.5	221	0.0180	0.67		**Shallow Concentrated Flow, Forest** Woodland Kv= 5.0 fps
18.2	1,041	Total			

Summary for Subcatchment 5S: Greendale Avenue

Runoff = 2.80 cfs @ 12.06 hrs, Volume= 0.195 af, Depth= 5.08"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100 YEAR Rainfall=6.70"

	Area (ac)	CN	Description
*	0.270	98	Pavement
	0.190	69	50-75% Grass cover, Fair, HSG B
	0.460	86	Weighted Average
	0.190		41.30% Pervious Area
	0.270		58.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.3	20	0.0200	0.98		**Sheet Flow, Pavement** Smooth surfaces n= 0.011 P2= 3.10"
4.2	600	0.0140	2.40		**Shallow Concentrated Flow, Gutter** Paved Kv= 20.3 fps
4.5	620	Total			

Summary for Reach 1R: Low Point

Inflow Area = 7.080 ac, 53.95% Impervious, Inflow Depth = 1.52" for 100 YEAR event
Inflow = 11.08 cfs @ 12.35 hrs, Volume= 0.899 af
Outflow = 11.08 cfs @ 12.35 hrs, Volume= 0.899 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Reach 2R: Catch Basin

Inflow Area = 0.460 ac, 58.70% Impervious, Inflow Depth = 5.08" for 100 YEAR event
Inflow = 2.80 cfs @ 12.06 hrs, Volume= 0.195 af
Outflow = 2.80 cfs @ 12.06 hrs, Volume= 0.195 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3

Summary for Pond 1P: Infiltration Chamber 1

Inflow Area = 1.090 ac, 63.30% Impervious, Inflow Depth = 4.86" for 100 YEAR event
Inflow = 6.30 cfs @ 12.07 hrs, Volume= 0.441 af
Outflow = 2.33 cfs @ 12.31 hrs, Volume= 0.441 af, Atten= 63%, Lag= 14.3 min
Discarded = 0.54 cfs @ 12.31 hrs, Volume= 0.384 af
Primary = 1.80 cfs @ 12.31 hrs, Volume= 0.057 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 138.61' @ 12.31 hrs Surf.Area= 1,914 sf Storage= 5,807 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 75.6 min (874.1 - 798.5)

Volume	Invert	Avail.Storage	Storage Description
#1	134.50'	2,770 cf	**22.00'W x 87.00'L x 6.00'H Crushed Stone** 11,484 cf Overall - 4,558 cf Embedded = 6,926 cf x 40.0% Voids
#2	135.00'	4,558 cf	**Cultec R-900HD** x 36 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		7,328 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	138.00'	**12.0" Round Pipe** L= 30.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 138.00' / 133.00' S= 0.1667 '/' Cc= 0.900 n= 0.011 Concrete pipe, straight & clean, Flow Area= 0.79 sf
#2	Discarded	134.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=0.54 cfs @ 12.31 hrs HW=138.61' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.54 cfs)

Primary OutFlow Max=1.80 cfs @ 12.31 hrs HW=138.61' TW=135.47' (Dynamic Tailwater)
↑—**1=Pipe** (Inlet Controls 1.80 cfs @ 3.61 fps)

Summary for Pond 2P: Infiltration Chamber 1a

Inflow Area = 3.120 ac, 71.47% Impervious, Inflow Depth = 3.74" for 100 YEAR event
Inflow = 12.73 cfs @ 12.07 hrs, Volume= 0.973 af
Outflow = 5.98 cfs @ 12.34 hrs, Volume= 0.973 af, Atten= 53%, Lag= 16.3 min
Discarded = 1.07 cfs @ 12.34 hrs, Volume= 0.702 af
Primary = 4.90 cfs @ 12.34 hrs, Volume= 0.272 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 135.50' @ 12.34 hrs Surf.Area= 3,454 sf Storage= 13,237 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 61.1 min (842.7 - 781.6)

Volume	Invert	Avail.Storage	Storage Description
#1	129.50'	4,987 cf	**22.00'W x 157.00'L x 6.00'H Crushed Stone** 20,724 cf Overall - 8,257 cf Embedded = 12,467 cf x 40.0% Voids
#2	130.00'	8,257 cf	**Cultec R-900HD** x 66 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		13,244 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	130.50'	**15.0" Round Pipe** L= 230.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 130.50' / 110.42' S= 0.0873 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	130.50'	**2.5" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	135.00'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir**

			Head (feet) 0.20 0.40 0.60 0.80 1.00
			Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	129.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=1.07 cfs @ 12.34 hrs HW=135.49' (Free Discharge)
↑—**4=Exfiltration** (Exfiltration Controls 1.07 cfs)

Primary OutFlow Max=4.90 cfs @ 12.34 hrs HW=135.49' TW=0.00' (Dynamic Tailwater)
↑—**1=Pipe** (Passes 4.90 cfs of 16.84 cfs potential flow)
↑—**2=Orifice #1** (Orifice Controls 0.73 cfs @ 10.65 fps)
—**3=Broad-Crested Rectangular Weir** (Weir Controls 4.17 cfs @ 2.11 fps)

Summary for Pond 3P: Infiltration Chamber 2

Inflow Area =	2.290 ac,	69.43% Impervious,	Inflow Depth =	5.19" for 100 YEAR event
Inflow =	13.93 cfs @	12.07 hrs,	Volume=	0.990 af
Outflow =	4.23 cfs @	12.38 hrs,	Volume=	0.990 af, Atten= 70%, Lag= 18.4 min
Discarded =	1.16 cfs @	12.38 hrs,	Volume=	0.735 af
Primary =	3.07 cfs @	12.38 hrs,	Volume=	0.255 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 116.82' @ 12.38 hrs Surf.Area= 3,916 sf Storage= 13,957 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 57.1 min (847.0 - 789.9)

Volume	Invert	Avail.Storage	Storage Description
#1	111.50'	5,652 cf	**22.00'W x 178.00'L x 6.00'H Crushed Stone** 23,496 cf Overall - 9,367 cf Embedded = 14,129 cf x 40.0% Voids
#2	112.00'	9,367 cf	**Cultec R-900HD** x 75 Inside #1 Effective Size= 72.7"W x 48.0"H => 17.61 sf x 7.00'L = 123.3 cf Overall Size= 78.0"W x 48.0"H x 9.25'L with 2.25' Overlap Row Length Adjustment= +2.25' x 17.61 sf x 3 rows
		15,018 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Primary	112.50'	**15.0" Round Pipe** L= 43.0' RCP, end-section conforming to fill, Ke= 0.500 Inlet / Outlet Invert= 112.50' / 110.25' S= 0.0523 '/' Cc= 0.900 n= 0.013, Flow Area= 1.23 sf
#2	Device 1	112.50'	**3.0" Vert. Orifice #1 X 2.00** C= 0.600
#3	Device 1	116.50'	**4.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#4	Discarded	111.50'	**8.270 in/hr Exfiltration over Wetted area**

Discarded OutFlow Max=1.16 cfs @ 12.38 hrs HW=116.82' (Free Discharge)
└**4=Exfiltration** (Exfiltration Controls 1.16 cfs)

Primary OutFlow Max=3.07 cfs @ 12.38 hrs HW=116.82' TW=0.00' (Dynamic Tailwater)
└**1=Pipe** (Passes 3.07 cfs of 11.36 cfs potential flow)
  ├**2=Orifice #1** (Orifice Controls 0.97 cfs @ 9.86 fps)
  └**3=Broad-Crested Rectangular Weir** (Weir Controls 2.10 cfs @ 1.63 fps)

Appendix C

StormCAD® Pipe Design

TETRA TECH
25 Year Storm

Project: Greendale Avenue
City: Needham
State: MA

Proj. No: 143-82806
Date: 8-Mar-13
Comp: CDH
Check :

Structure	Pavement / Roof Area (acres)	Pavement / Roof C Factor	Grass / Pervious Area (acres)	Grass / Pervious C Factor	Forest Area (acres)	Forest C Factor	Total Area (acres)	Composite C	Q (cfs)
CB-1	0.08	0.98	0.16	0.50	0.00	0.40	0.24	0.66	0.95
CB-2	0.17	0.98	0.05	0.50	0.00	0.40	0.22	0.87	1.15
CB-3	0.13	0.98	0.04	0.50	0.00	0.40	0.17	0.87	0.88
CB-4	0.17	0.98	0.07	0.50	0.00	0.40	0.24	0.84	1.21
CB-5	0.16	0.98	0.10	0.50	0.00	0.40	0.26	0.80	1.24
CB-6	0.05	0.98	0.03	0.50	0.00	0.40	0.08	0.80	0.38
CB-7	0.14	0.98	0.03	0.50	0.00	0.40	0.17	0.90	0.91
CB-8	0.24	0.98	0.17	0.50	0.00	0.40	0.41	0.78	1.92
CB-9	0.10	0.98	0.09	0.50	0.00	0.40	0.19	0.75	0.86
CB-10	0.07	0.98	0.14	0.50	0.00	0.40	0.21	0.66	0.83
AD-1	0.06	0.98	0.03	0.50	0.00	0.40	0.09	0.82	0.44
AD-2	0.06	0.98	0.05	0.50	0.00	0.40	0.11	0.76	0.50
AD-3	0.06	0.98	0.03	0.50	0.00	0.40	0.09	0.82	0.44
AD-4	0.05	0.98	0.03	0.50	0.00	0.40	0.08	0.80	0.38
AD-5	0.07	0.98	0.00	0.50	0.00	0.40	0.07	0.98	0.41
AD-6	0.07	0.98	0.00	0.50	0.00	0.40	0.07	0.98	0.41
AD-7	0.08	0.98	0.00	0.50	0.00	0.40	0.08	0.98	0.47
AD-8	0.08	0.98	0.00	0.50	0.00	0.40	0.08	0.98	0.47
AD-9	0.09	0.98	0.09	0.50	0.00	0.40	0.18	0.74	0.80
AD-10	0.07	0.98	0.00	0.50	0.00	0.40	0.07	0.98	0.41
AD-11	0.07	0.98	0.00	0.50	0.00	0.40	0.07	0.98	0.41
BLDG A	0.21	0.98	0.00	0.50	0.00	0.40	0.21	0.98	1.23
BLDG B	0.21	0.98	0.00	0.50	0.00	0.40	0.21	0.98	1.23
BLDG C	0.27	0.98	0.00	0.50	0.00	0.40	0.27	0.98	1.59
BLDG D	0.63	0.98	0.00	0.50	0.00	0.40	0.63	0.98	3.70
BLDG E	0.28	0.98	0.00	0.50	0.00	0.40	0.28	0.98	1.65
BLDG F	0.47	0.98	0.00	0.50	0.00	0.40	0.47	0.98	2.76
BLDG G	0.14	0.98	0.00	0.50	0.00	0.40	0.14	0.98	0.82
TOTAL	**4.03**		**0.90**		**0.00**		**4.93**		

Notes:
1.) Shaded columns indicate input values
2.) Storm Event = 25 Year
3.) Q = Flow = C x I x Area,
where I = 6.0 inches/hour (5 min. duration) for the 25 year storm event

Greendale Avenue - Needham, MA

Label	Upstream Structure	Upstream Structure Rim Elevation (ft)	Downstream Structure	Downstream Structure Rim Elevation (ft)	Length (ft)	Diameter (in)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Slope (ft/ft)	Flow (ft³/s)	Capacity (Full Flow) (ft³/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Velocity (Average) (ft/s)
P-53	CB-1	147.00	STC-1	147.00	15	12	143.00	142.85	0.010	0.95	4.63	143.41	143.17	4.64
P-54	STC-1	147.00	DMH-3	146.85	3	12	142.75	138.13	1.540	0.95	57.47	143.16	138.85	27.37
P-58	AD-6	141.50	AD-5	141.50	57	10	139.41	139.13	0.005	0.41	2.00	139.69	139.39	2.88
P-59	AD-5	141.50	DMH-5	141.30	9	10	139.13	139.08	0.006	0.41	2.12	139.41	139.40	3.01
P-62	BLDG E-2	142.50	DMH-5	141.30	25	10	139.50	139.08	0.017	0.57	3.69	139.83	139.31	4.91
P-63	DMH-5	141.30	DMH-4	146.10	130	12	138.98	138.33	0.005	0.98	3.27	139.40	138.84	3.64
P-80	BLDG E	146.00	DMH-4	146.10	25	10	138.63	138.33	0.012	0.60	3.12	138.97	138.84	4.42
P-57	DMH-4	146.10	DMH-3	146.85	20	12	138.23	138.13	0.005	1.58	3.27	138.84	138.85	4.13
P-75	BLDG B	154.00	AD-2	154.00	25	10	151.50	151.10	0.016	0.48	3.60	151.80	151.31	4.59
P-40	AD-2	154.00	AD-1	154.00	82	10	151.00	150.18	0.010	0.50	2.85	151.31	150.42	3.93
P-76	BLDG-A	154.00	AD-1	154.00	25	10	150.50	150.18	0.013	0.48	3.22	150.80	150.40	4.24
P-41	AD-1	154.00	DMH-1	154.00	114	12	150.08	148.94	0.010	0.44	4.63	150.35	149.15	3.71
P-42	DMH-1	154.00	DMH-2	147.20	106	12	148.84	143.20	0.053	0.44	10.68	149.11	143.34	6.69
P-65	BLDG A	144.00	DMH-2	147.20	37	10	138.87	138.33	0.015	0.71	3.44	139.24	138.83	4.97
P-2	DMH-2	147.20	DMH-3	146.85	7	12	138.23	138.13	0.014	1.15	5.54	138.83	138.85	5.56
P-64	DMH-3	146.85	INF-1B	146.00	3	12	138.03	138.00	0.010	3.68	4.63	138.85	138.76	6.55
RL-B	BLDG B	139.00	INF-1A	137.50	30	12	133.93	133.00	0.031	0.70	8.15	134.28	133.20	6.35
P-85	BLDG-F	143.00	DMH-6	137.15	25	12	135.00	134.00	0.040	0.53	9.26	135.30	134.16	6.40
P-84	CB-2	140.90	CB-3	137.00	118	12	136.90	133.48	0.029	1.15	7.88	137.35	133.74	7.16
P-3	CB-3	137.00	STC-2	137.50	2	12	133.38	133.28	0.050	0.88	10.36	133.77	133.80	8.04
P-81	CB-4	138.00	STC-2	137.50	53	12	134.00	133.28	0.014	1.21	5.40	134.46	133.80	5.54
P-82	STC-2	137.50	DMH-6	137.15	3	12	133.18	133.16	0.007	2.09	3.78	133.80	133.74	4.94
P-83	DMH-6	137.15	INF-1A	137.50	12	15	133.06	133.00	0.005	2.62	5.94	133.71	133.60	4.69
RL-9	BLDG C-1	140.00	DMH-7	140.00	30	12	136.15	136.00	0.005	0.55	3.27	136.77	136.77	3.09
P-77	BLDG-C	153.00	AD-3	153.00	25	10	149.50	149.10	0.016	0.26	3.60	149.72	149.25	3.84
P-43	AD-3	153.00	AD-4	152.00	92	10	149.00	148.00	0.011	0.44	2.97	149.29	148.22	3.90
P-78	BLDG-C	152.00	AD-4	152.00	25	10	148.50	148.00	0.020	0.47	4.03	148.80	148.19	4.93
P-44	AD-4	152.00	DMH-9	148.80	96	12	147.90	144.80	0.032	0.38	8.32	148.15	144.95	5.37
P-45	DMH-9	148.80	DMH-8	142.30	117	12	144.70	138.30	0.055	0.38	10.83	144.95	138.43	6.47
P-66	CB-5	142.20	STC-3	142.30	5	12	138.20	138.10	0.020	1.24	6.55	138.67	138.47	6.41
P-67	STC-3	142.30	DMH-8	142.30	9	12	138.00	137.91	0.010	1.24	4.63	138.47	138.41	5.00
P-79	BLDG C-2	142.00	DMH-8	142.30	25	10	138.20	137.91	0.012	0.33	3.07	138.45	138.41	3.67
P-68	DMH-8	142.30	DMH-7	140.00	108	12	137.81	136.00	0.017	1.95	6.00	138.41	136.77	6.82
RL-8	BLDG D	142.00	DMH-7	140.00	14	10	136.50	136.00	0.036	0.40	5.38	136.78	136.77	5.78
P-71	AD-8	140.50	AD-7	140.50	43	10	136.50	136.26	0.006	0.47	2.13	136.80	136.77	3.13
P-73	AD-7	140.50	DMH-7	140.00	32	12	136.16	136.00	0.005	0.47	3.27	136.77	136.77	2.96
P-74	BLDG D	139.50	DMH-7	140.00	50	10	136.50	136.00	0.010	0.89	2.85	136.92	136.77	4.62
P-69	DMH-7	140.00	INF-1A	137.50	146	12	135.90	133.00	0.020	4.26	6.53	136.77	133.59	8.85
P-98	BLDG-D	122.00	DMH-12	119.75	25	12	117.00	115.67	0.053	1.80	10.68	117.57	116.55	10.10
P-97	BLDG-F	122.00	DMH-12	119.75	25	10	116.00	115.67	0.013	0.75	3.27	116.54	116.55	4.87
P-39	CB-8	119.50	STC-4	119.70	10	12	115.82	115.70	0.012	1.92	5.07	116.51	116.55	6.01
P-92	CB-10	125.50	DMH-11	120.50	219	12	121.50	116.50	0.023	0.83	7.00	121.88	117.02	5.99
P-11	CB-6	129.40	DMH-10	129.00	10	12	125.40	125.00	0.040	0.38	9.26	125.65	125.38	5.79
P-12	CB-7	129.40	DMH-10	129.00	10	12	125.40	125.00	0.040	0.91	9.26	125.80	125.25	7.50
P-13	DMH-10	129.00	DMH-11	120.50	87	12	124.90	116.50	0.097	1.29	14.39	125.38	117.02	11.35
P-19	DMH-11	120.50	STC-4	119.70	23	12	116.40	115.70	0.030	2.12	8.08	117.02	116.55	8.67
P-93	STC-4	119.70	DMH-12	119.75	3	12	115.70	115.67	0.010	4.04	4.63	116.55	116.55	6.65
P-49	AD-11	142.00	CLEANOUT	119.80	37	12	140.00	116.40	0.638	0.41	36.99	140.26	116.72	15.67
P-95	BLDG-F	126.00	CLEANOUT	119.80	25	10	117.00	116.30	0.028	0.57	4.77	117.33	116.72	5.89
P-96	CLEANOUT	119.80	DMH-12	119.75	46	12	116.30	115.57	0.016	0.98	4.49	116.72	116.55	4.57
P-94	DMH-12	119.75	INF-2	119.60	18	12	115.57	115.00	0.032	7.57	8.24	116.55	115.86	11.91
P-86	CB-9	128.50	STC-5	129.00	11	12	124.50	124.28	0.020	0.86	6.55	124.89	124.55	5.77
P-87	STC-5	129.00	DMH-14	129.00	6	12	124.18	124.06	0.020	0.86	6.55	124.57	124.35	5.77
P-90	BLDG-E	141.00	DMH-14	129.00	25	12	137.00	124.06	0.518	1.05	33.32	137.43	124.18	19.30
P-52	AD-10	142.00	CLEANOUT	130.00	37	12	140.00	125.00	0.405	0.41	29.49	140.26	125.08	13.37
P-91	BLDG-E	142.00	CLEANOUT	130.00	17	12	126.00	125.00	0.059	0.57	11.23	126.31	125.16	7.49
P-51	CLEANOUT	130.00	DMH-14	129.00	82	12	124.50	124.06	0.005	0.98	3.39	124.92	124.43	3.73

Greendale Avenue - Needham, MA

Label	Upstream Structure	Upstream Structure Rim Elevation (ft)	Downstream Structure	Downstream Structure Rim Elevation (ft)	Length (ft)	Diameter (in)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Slope (ft/ft)	Flow (ft^3/s)	Capacity (Full Flow) (ft^3/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Velocity (Average) (ft/s)
P-89	AD-9	141.00	DMH-14	129.00	53	10	138.66	124.05	0.275	0.80	14.95	139.06	124.19	14.57
P-88	DMH-14	129.00	INF-2	127.00	7	12	115.21	115.00	0.030	3.69	8.02	116.03	115.63	10.00

Appendix D

Groundwater Recharge Calculations

Calc. By: CDH Date: 28-Mar-13
Chk. By: Date:

Greendale Avenue
Needham, MA

Groundwater Recharge Calculations

Required Recharge Volume[1]

Rv = F x impervious area

Where: Rv = required recharge volume (acre-feet)
F = target depth factor associated with each hydrologic soil group (inches)
Impervious Area = pavement and rooftop area on site (acres)

NRCS Hydrologic Soil Type	Approx. Soil Texture	Target Depth Factor (inches)	Impervious Area (acre)	Rv (acre-feet)	Rv (cf)
A	sand	0.60	4.09	0.205	8,908
B	loam	0.35	0.00	0.000	0
C	silty loam	0.25	0.00	0.000	0
D	clay	0.10	0.00	0.000	0
		Total =	**4.09**	**0.205**	**8,908**

Provided Recharge Volume[2]

Infiltration Chamber	Static Storage Volume (acre-feet)	Static Storage Volume (cf)
1	0.116	5,065
2	0.051	2,202
3	0.057	2,498
Total =	**0.224**	**9,765**

Notes:
1.) Refer to Massachusetts Stormwater Handbook Volume 3, Chapter 1, page 15 dated February 2008.
2.) Provided recharge volume is based on the Static Method, refer to Massachusetts Stormwater Handbook Volume 3, Chapter 1, page 18 dated February 2008.

Rawls Rates

Texture Class	NRCS Hydrologic Soil Group (HSG)	Infiltration Rate (inches/hour)
sand	A	8.27
loamy sand	A	2.41
sandy loam	B	1.02
loam	B	0.52
silt loam	C	0.27
sandy clay loam	C	0.17
clay loam	D	0.09
silty clay loam	D	0.06
sandy clay	D	0.05
silty clay	D	0.04
clay	D	0.02

Refer to Massachusetts Stormwater Handbook Volume 3, Chapter 1, page 22 dated February 2008.

Calc. By: CDH Date: 28-Mar-13
Chk. By: _____ Date: _____

Greendale Avenue
Needham, MA

Drawdown Calculations

Drawdown Time[1]

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

Where: $Time_{drawdown}$ = time it takes the basin to drain completely (hours)
Rv = static storage volume (cubic feet)
K = saturated hydraulic conductivity[2] (inches/hour)
Bottom Area = bottom area of recharge structure (square feet)

Infiltration Chamber	Rv (cf)	K (in/hr)	Bottom Area (sf)	Drawdown Time (hr)
1	5,065	8.27	1,914	3.8
2	2,202	8.27	3,454	0.9
3	2,498	8.27	3,916	0.9

Notes:
1.) Refer to Massachusetts Stormwater Handbook Volume 3, Chapter 1, page 25 dated February 2008.
2.) Refer to Massachusetts Stormwater Handbook Volume 3, Chapter 1, page 22 dated February 2008 (Rawls Rates Table).

Appendix E

Water Quality Calculations

Calc. By: CDH Date: 28-Mar-13
Chk. By: _____ Date: _____

Greendale Avenue
Needham, MA

Water Quality Volume Calculations

Infiltration Chamber	A_{IMP} (acres)	D_{WQ} (inches)	V_{WQ} (cubic feet)	Provided Volume (cubic feet)
1	0.83	0.50	1,506	5,065
2	1.54	0.50	2,795	2,202
3	1.59	0.50	2,886	2,498
Total	**3.13**		**5,681**	**9,765**

$V_{WQ} = (D_{WQ} / 12 \text{ inches/foot}) * (A_{IMP} * 43{,}560 \text{ square feet/acre})$

Where: V_{WQ} = Required Water Quality Volume (in cubic feet)
D_{WQ} = Water Quality Depth (in inches)
A_{IMP} = Impervious Area (in acres)

Notes:
1.) Refer to Massachusetts Stormwater Handbook Volume 3, Chapter 1, page 32 dated February 2008.

Tetra Tech

Project: **Needham Mews** By: **GKD** Date: **3/14/2013**

Location: **Needham, MA** Chkd: Date:

TSS Removal Calculation Worksheet

A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (BxC)	E Remaining Load (C-D)
Street Sweeping		1.00		1.00
Deep Sump/Hooded Catchbasins	0.25	1.00	0.250	0.75
Water Quality Structures	0.50	0.75	0.375	0.38
Subsurface Infiltration Basin	0.80	0.38	0.300	0.08

* Equals remaining load from previous BMP

Total TSS Removal = **92.5%**

Source: Volume Two: Massachusetts Stormwater Handbook, Dated January 2009
prepared by MADEP, Section VI Case studies.

TSS Removal Efficiencies for Best Management Practices	
Best Management Practice (BMP)	**TSS Removal Efficiency**
Non-Structural Pretreatment BMPs	
Street Sweeping	0-10%, See Volume 2, Chapter 1.
Structural Pretreatment BMPs	
Deep Sump Catch Basins	25% only if used for pretreatment and only if off-line
Oil Grit Separator	25% only if used for pretreatment and only if off-line
Proprietary Separators	Varies – see Volume 2, Chapter 4.
Sediment Forebays	25% if used for pretreatment
Vegetated filter strips	10% if at least 25 feet wide, 45% if at least 50 feet wide
Treatment BMPs	
Bioretention Areas including rain gardens	90% provided it is combined with adequate pretreatment
Constructed Stormwater Wetlands	80% provided it is combined with a sediment forebay
Extended Dry Detention Basins	50% provided it is combined with a sediment forebay
Gravel Wetlands	80% provided it is combined with a sediment forebay
Proprietary Media Filters	Varies – see Volume 2, Chapter 4
Sand/Organic Filters	80% provided it is combined with sediment forebay
Treebox filter	80% provided it is combined with adequate pretreatment
Wet Basins	80% provided it is combined with sediment forebay
Conveyance	
Drainage Channels	For conveyance only. No TSS Removal credit.
Grass Channels (formerly biofilter swales)	50% if combined with sediment forebay or equivalent
Water Quality Swale – wet & dry	70% provided it is combined with sediment forebay or equivalent
Infiltration BMPs	
Dry Wells	80% for runoff from non-metal roofs; may also be used for runoff from metal roofs but only if metal roof is not located within a Zone II, or IWPA or at an industrial site
Infiltration Basins & Infiltration Trenches	80% provided it is combined with adequate pretreatment (sediment forebay or vegetated filter strip, grass channel, water quality swale) prior to infiltration
Leaching Catch Basins	80% provided a deep sump catch basin is used for pretreatment
Subsurface Structure	80% provided they are combined with one or more pretreatment BMPs prior to infiltration.
Other BMPs	
Dry Detention Basins	For peak rate attenuation only. No TSS Removal credit.

TESTING SUMMARY

Massachusetts Strategic Envirotechnology Partnership (STEP) Program Stormceptor® Report

Summary: The Massachusetts STEP Program has completed a six-month evaluation of the function and performance tests of Stormceptor. Upon the completion of the evaluation and verification program, which occurred during the end of December 1997, the STEP Program summarized its findings as follows:

- Performance data available demonstrates that the Stormceptor System can provide TSS removal rates of 77% when sized according to the "Sensitive Area" criteria.
- Evidence suggests that the Stormceptor System may be capable of achieving TSS removal rates between 89% and 99% under certain climate conditions and land use intensity when sized accordingly.
- Performance data available suggest that the Stormceptor System can provide TSS removal rates of 52% when sized according to the "Treatment Train" criteria.
- Use of the Stormceptor System as a stand-alone device may be justified when sized according to the Sensitive Area criteria.
- The Stormceptor System is useful for new and retrofit installations in Standard 7 of DEP's Stormwater Management Policy and Standards (DEP and CZM 1997), especially where space is limited.
- The Stormceptor System is also suited for secondary sediment control from construction related sediment loads specified in Standard 8 of DEP's Stormwater Management Policy and Standards.

In March 1997, the Massachusetts Department of Environmental Protection (DEP) issued Stormwater Management Standards* to address both qualitative and quantitative controls to protect waters of the Commonwealth of Massachusetts from impacts of untreated stormwater runoff. Local Conservation Commissions will implement DEP's new Stormwater Policy through the Standards. The Standards establish the level of required controls that can be achieved primarily through the installation of Best Management Practices (BMPs).

Opportunities exist for the use of innovative stormwater technologies such as the Stormceptor System, especially in areas where site constraints make it very difficult to install the more typical BMPs such as retention ponds. With the increase in the use of innovative technologies, DEP has entered into an agreement with the Commonwealth's Strategic Envirotechnology Partnership (STEP) Program to allow for the verification of the function and performance of stormwater innovative systems. Upon verification by the STEP Program, local Conservation Commissions are allowed to accept the use of the innovative systems. DEP also allows for independent verification by local conservation commissions. The Massachusetts STEP is part of a six-state partnership for Environmental Technology including Illinois, California, Pennsylvania, New Jersey and New York.

In summary, the Massachusetts STEP Program reports that the Stormceptor System "should be capable of providing an effective solution for treatment of stormwater runoff" (STEP TECHNOLOGY ASSESSMENT, DRAFT REPORT, DECEMBER 1997).

*Standards issued in March, 1997 by the Massachusetts DEP, available upon request

Stormceptor®

Stormceptor Design Summary

PCSWMM for Stormceptor

Project Information

Date	3/21/2013
Project Name	692 / 744 Greendale Avenue
Project Number	143-82806-13003
Location	Needham, MA

Designer Information

Company	Tetra Tech
Contact	Dave Hudson

Notes

STC-1

Drainage Area

Total Area (ac)	0.24
Imperviousness (%)	0.1

The Stormceptor System model STC 450i achieves the water quality objective removing 100% TSS for a Fine (organics, silts and sand) particle size distribution.

Rainfall

Name	BLUE HILL
State	MA
ID	736
Years of Records	1948 to 2005
Latitude	42°12'44"N
Longitude	71°6'53"W

Water Quality Objective

TSS Removal (%)	80

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	**100**
STC 900	100
STC 1200	100
STC 1800	100
STC 2400	100
STC 3600	100
STC 4800	100
STC 6000	100
STC 7200	100
STC 11000	100
STC 13000	100
STC 16000	100

Rinker MATERIALS™

Stormceptor®

Stormceptor Design Summary

PCSWMM for Stormceptor

Project Information

Date	3/21/2013
Project Name	692 / 744 Greendale Avenue
Project Number	143-82806-13003
Location	Needham, MA

Designer Information

Company	Tetra Tech
Contact	Dave Hudson

Notes

STC-2

Drainage Area

Total Area (ac)	0.64
Imperviousness (%)	75

The Stormceptor System model STC 450i achieves the water quality objective removing 84% TSS for a Fine (organics, silts and sand) particle size distribution.

Rainfall

Name	BLUE HILL
State	MA
ID	736
Years of Records	1948 to 2005
Latitude	42°12'44"N
Longitude	71°6'53"W

Water Quality Objective

TSS Removal (%)	80

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	**84**
STC 900	90
STC 1200	90
STC 1800	90
STC 2400	92
STC 3600	93
STC 4800	94
STC 6000	95
STC 7200	96
STC 11000	97
STC 13000	97
STC 16000	98

Rinker MATERIALS™

Stormceptor®

Stormceptor Design Summary

PCSWMM for Stormceptor

Project Information

Date	3/21/2013
Project Name	692 / 744 Greendale Avenue
Project Number	143-82806-13003
Location	Needham, MA

Designer Information

Company	Tetra Tech
Contact	Dave Hudson

Notes

STC-3

Drainage Area

Total Area (ac)	0.26
Imperviousness (%)	54

The Stormceptor System model STC 450i achieves the water quality objective removing 92% TSS for a Fine (organics, silts and sand) particle size distribution.

Rainfall

Name	BLUE HILL
State	MA
ID	736
Years of Records	1948 to 2005
Latitude	42°12'44"N
Longitude	71°6'53"W

Water Quality Objective

TSS Removal (%)	80

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	**92**
STC 900	95
STC 1200	95
STC 1800	96
STC 2400	97
STC 3600	97
STC 4800	98
STC 6000	98
STC 7200	98
STC 11000	99
STC 13000	99
STC 16000	99

Rinker MATERIALS™

Stormceptor®

Stormceptor Design Summary

PCSWMM for Stormceptor

Project Information

Date	3/21/2013
Project Name	692 / 744 Greendale Avenue
Project Number	143-82806-13003
Location	Needham, MA

Designer Information

Company	Tetra Tech
Contact	Dave Hudson

Notes

STC-4

Drainage Area

Total Area (ac)	0.9
Imperviousness (%)	50

The Stormceptor System model STC 450i achieves the water quality objective removing 85% TSS for a Fine (organics, silts and sand) particle size distribution.

Rainfall

Name	BIRCH HILL DAM
State	MA
ID	666
Years of Records	1948 to 2005
Latitude	42°38'0"N
Longitude	72°7'0"W

Water Quality Objective

TSS Removal (%)	80

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	**85**
STC 900	90
STC 1200	91
STC 1800	91
STC 2400	93
STC 3600	93
STC 4800	95
STC 6000	95
STC 7200	96
STC 11000	97
STC 13000	97
STC 16000	98

Rinker MATERIALS™

Stormceptor®

Stormceptor Design Summary

PCSWMM for Stormceptor

Project Information

Date	3/21/2013
Project Name	692 / 744 Greendale Avenue
Project Number	143-82806-13003
Location	Needham, MA

Designer Information

Company	Tetra Tech
Contact	Dave Hudson

Notes

STC-5

Drainage Area

Total Area (ac)	0.2
Imperviousness (%)	55

The Stormceptor System model STC 450i achieves the water quality objective removing 93% TSS for a Fine (organics, silts and sand) particle size distribution.

Rainfall

Name	BLUE HILL
State	MA
ID	736
Years of Records	1948 to 2005
Latitude	42°12'44"N
Longitude	71°6'53"W

Water Quality Objective

TSS Removal (%)	80

Upstream Storage

Storage (ac-ft)	Discharge (cfs)
0	0

Stormceptor Sizing Summary

Stormceptor Model	TSS Removal %
STC 450i	93
STC 900	96
STC 1200	96
STC 1800	96
STC 2400	97
STC 3600	97
STC 4800	98
STC 6000	98
STC 7200	99
STC 11000	99
STC 13000	99
STC 16000	99

Rinker MATERIALS™

Appendix F

Operations and Maintenance Plan

Operations and Maintenance Plan
Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Submitted to:
Town of Needham

April 12, 2013

Table of Contents

1.0 Introduction

This long-term Stormwater Management System Operations and Maintenance (O&M) Plan, filed with the Town of Needham, shall be implemented at the Needham Mews residential community development at 692 & 744 Greendale Avenue to ensure that the stormwater management system functions as designed. The Owner possesses the primary responsibility for overseeing and implementing the O&M Plan and assigning a Property Manager who will be responsible for the proper operation and maintenance of the stormwater structures. In case of transfer of property ownership, future property owners shall be notified of the presence of the stormwater management system and the requirements for proper implementation of the O&M Plan. Included in the manual is a log for tracking inspections and maintenance of key components of the stormwater management system.

The stormwater management system protects and enhances the stormwater runoff water quality through the removal of sediment and pollutants, and source control significantly reduces the amount of pollutants entering the system. Preventive maintenance of the system will include a comprehensive source reduction program of regular pavement sweeping and litter removal, prohibitions on the use of pesticides, and maintenance of designated waste and recycling areas.

1.1 Responsibility

The purpose of the Stormwater Operations and Maintenance (O&M) plan is to ensure inspections of the system, removal of accumulated sediments, oils, and debris, and implementation of corrective action and record keeping activities. The ongoing responsibility is the Owner, its successors and assigns. Adequate maintenance is defined in this document as good working condition.

Owner contact information is provided below:

Responsibility for Operations and Maintenance

Name:	Greendale Avenue Venture LLC c/o Mill Creek Residential Trust, LLC
Address:	15 New England Executive Park
City, State:	Burlington, MA 01803
Contact:	Robert D. Hewitt
Telephone:	(781) 685-4698

1.2 Documentation

An Inspection and Maintenance Record Log and Schedule will be kept by the Owner or Property Manager summarizing inspections, maintenance, repairs and any corrective actions taken. The log will include the date on which each inspection or maintenance task was performed, a description of the inspection findings or maintenance completed, and the name of the inspector or maintenance personnel performing the task. If a

maintenance task requires the clean-out of any sediments or debris, the location where the sediment and debris was disposed after removal will be indicated. Inspection & Maintenance Logs will be kept on file at the on-site Property Management office.

The Town of Needham has the right to enter the property at reasonable times and in a reasonable manner for the purpose of inspecting the stormwater management components and to review the Inspection and Maintenance Log.

2.0 Maintenance Program

The Owner, Property Manager and maintenance staff will conduct the Operation and Maintenance program set forth in this document. The Owner or Property Manager will ensure that inspections and record keeping are timely and accurate and that cleaning and maintenance are performed in accordance with the recommended frequency for each stormwater component. The Owner or Property Manager will also maintain all drainage components to function as they were designed to. Inspection & Maintenance Log Forms (provided herein) shall include the date and the amount of the last significant storm event in excess of 1" of rain in a 24-hour period, physical conditions of the structures, depth of sediment in structures, evidence of overtopping or debris blockage and maintenance required of each structure. Estimated annual cost of the Maintenance Program is $3,000 to $5,000.

2.1 Inspection and Maintenance Frequency

The following areas, facilities and measures will be inspected by the Owner or Property Manager and maintained as specified below. Identified deficiencies will be corrected. Accumulated sediments and debris will be properly handled and disposed of off-site, in accordance with local, state, and federal guidelines and regulations.

2.1.1 Yard Drains

Yard drains are incorporated into the stormwater management system to collect runoff from landscape areas. The drains are located in low-gradient areas and tie into the storm drainage piping system. The yard drains should be clear of any obstruction or debris in order to operate properly. Typical observations that would indicate that yard drains are not functioning properly are: sediment/trash accumulation around the inlet, vegetation growth within the yard drain and puddles around the yard drain grates after a storm event.

Yard drains will be inspected twice per year (April and October) to ensure that they are working in their intended fashion and free of debris. Sediments will be properly handled and disposed of off-site. The method of sediment removal will be by manual or vacuum as necessary and disposal must be documented. Any structural damage to drains or to castings must be repaired upon discovery.

2.1.2 Catch Basins

Catch basins with 4-foot deep sumps and hooded outlets will be inspected twice per year (April and October) and cleaned when sediment reaches ½ full depth from the invert of the pipe to ensure that the catch basins are working in their intended fashion and that they are free of debris. The basin outlet equipped with a hood/tee to trap floatable materials should be checked to ensure that the watertight seal is working. Sediments and hydrocarbons will be properly handled and disposed of off-site, in accordance with local, state, and federal guidelines and regulations. The method of sediment removal will be by vacuum and disposal must be documented. Any structural damage to catch basins or to castings must be repaired upon discovery.

2.1.3 Drain Manholes

Drain manholes shall be inspected on twice per year (April and October). Collection of accumulated sediment and hydrocarbons will be accomplished by means of vacuum pumping. Disposal of accumulated sediment and hydrocarbons will be performed in accordance with applicable local, state and federal regulations. Any structural damage to drain manholes or to castings must be repaired upon discovery.

2.1.4 Stormceptor® Water Quality Structures

Stormceptor units will be inspected twice per year (April and October) and cleaned when the sediment depth reaches 15% of storage capacity. Sediments and hydrocarbons will be properly handled and disposed of off-site in accordance with local, state and federal guidelines and regulations. In addition, inspections must be made immediately after an oil, fuel or chemical spill. A licensed waste management company must remove captured petroleum waste products and dispose responsibly in accordance with local, state and federal guidelines and regulations.

2.1.5 Subsurface Infiltration Systems

The Cultec Recharger 900HD subsurface infiltration systems will be inspected twice per year (April and October) by removing the inspection port cover located over the inlet row to provide access to the Cultec chambers below. Through this access port, a stadia rod may be used to measure depth of accumulated sediment. Cleaning is required if the depth of sediment is in excess of 3 inches and is accomplished through an upstream manhole utilizing a high-pressure culvert cleaning nozzle. The inlet row of the Cultec system is placed on a polyethylene liner to facilitate the flushing and prevent scouring of the washed stone beneath this row. The culvert cleaning nozzle is deployed through an upstream manhole and extended to the end of the row. The water is turned on and the inlet row is flushed back into the manhole and removed using a vacuum truck. Sediments and hydrocarbons will be properly handled and disposed of off-site in accordance with local, state and federal guidelines and regulations.

2.1.6 Flared End Outlets

A flared end outlet with rip rap stone is provided at the drainage outfall at the low-gradient end of the site. Typical observations that would indicate that the flared end outlet is not functioning properly are: sediment/trash accumulation around the outlet, erosion, vegetation growth through the rip rap, and dislodged rip rap. Flared end outlets and rip rap will be inspected twice per year (April and October) or as necessary to ensure that they are working in their intended fashion and free of debris. Remove any obstructions to flow; remove accumulated sediments and debris at the outlet and within the conduit and repair any erosion damage.

2.1.7 Vegetated Embankment Areas

Inspect slopes and embankments early in the growing season to identify active or potential erosion problems. Replant bare areas or areas with sparse growth. If erosion is evident, armor the area with an appropriate lining or riprap stone.

2.1.8 Site Access Drive

Accumulations of sand and debris will be cleared from the paved site access drives through mechanical sweeping to control the amount of sediment that enters the drainage system. Pavement sweeping will be conducted twice per year (April and October) or more often as necessary. Sweeping is most important in Spring after winter snowmelt when road sand and other sediments have accumulated.

3.0 Sample Inspection Forms

Inspection and Maintenance Log

INSPECTOR: _____ YEAR: _____

RAINFALL INSPECTION DATE: _____ RAINFALL AMOUNT: _____

Component to be inspected	Frequency	Date Performed	Action to be Taken	Comments
Yard Drains	Inspections Twice per Year	April and October	Remove sediment and debris	
Catch Basins	Inspections Twice per Year	April and October	Remove sediment and debris	
Drain Manholes	Inspections Twice per Year	April and October	Remove sediment and debris	
Stormceptors	Inspections Twice per Year	April and October	Maintenance as necessary-remove sediment and hydrocarbons	
Subsurface Infiltration Cultec Systems	Inspections Twice per Year	April and October	Maintenance as necessary-power flush and remove sediment	
Flared End Outlets	Inspections Twice per Year	April and October	Remove sediment and debris	
Vegetated Areas	Inspections Twice per Year	April and October	Replant bare spots and eroded areas as necessary	
Site Access Drive	Inspections Twice per Year	April and October	Street Sweeping	

YARD DRAIN INSPECTION FORM

Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Owner: _____

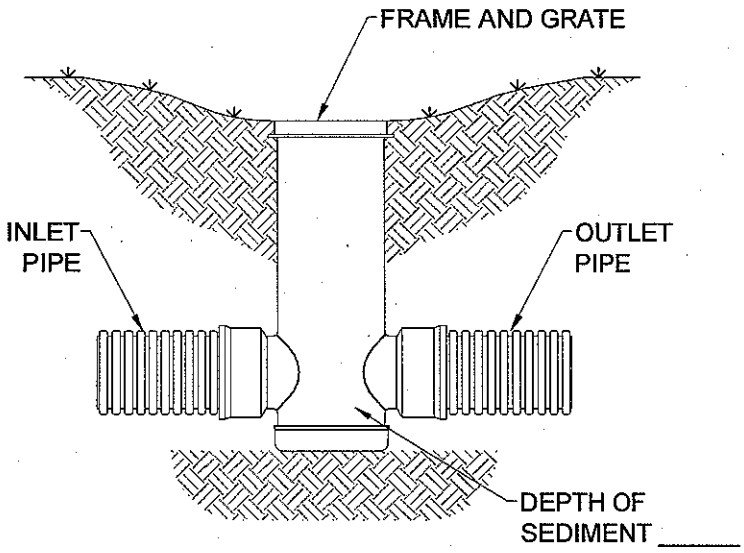
Property Manager: _____

Inspected By: _____

Date of Inspection: _____

Yard Drain Inspected: _____

	Acceptable	Needs Work	Notes



Date of Cleaning: _____ By Whom: _____

Date of Repair: _____ By Whom: _____

Note any discrepancies and suggested corrective actions:

_____

_____

_____

_____

_____

_____

CATCH BASIN INSPECTION FORM

Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Owner: _____

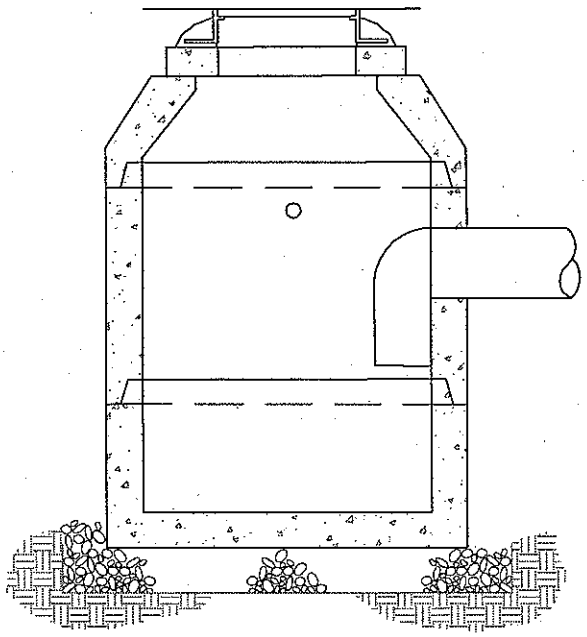
Property Manager: _____

Inspected By: _____

Date of Inspection: _____

Catch Basin Inspected: _____

	Acceptable	Needs Work	Notes



Date of Cleaning: _____ By Whom: _____

Date of Repair: _____ By Whom: _____

Note any discrepancies and suggested corrective actions:

_____

_____

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_____

_____

_____

DRAIN MANHOLE INSPECTION FORM

Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Owner: _____

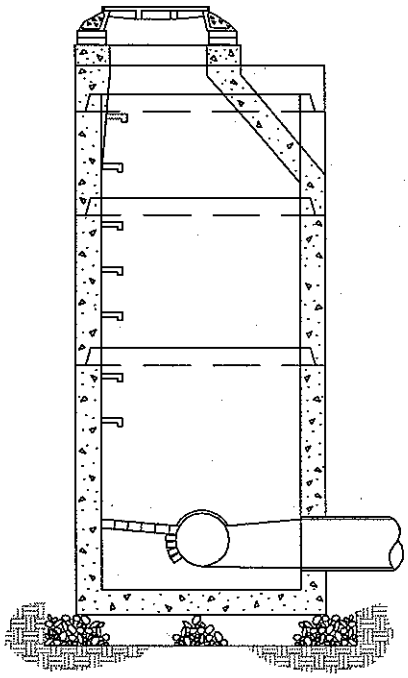
Property Manager: _____

Inspected By: _____

Date of Inspection: _____

Drain Manhole Inspected: _____

	Acceptable	Needs Work	Notes



Date of Cleaning: _____ By Whom: _____

Date of Repair: _____ By Whom: _____

Note any discrepancies and suggested corrective actions:

_____

_____

_____

_____

_____

_____

STORMCEPTOR INSPECTION FORM

Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Owner: _____

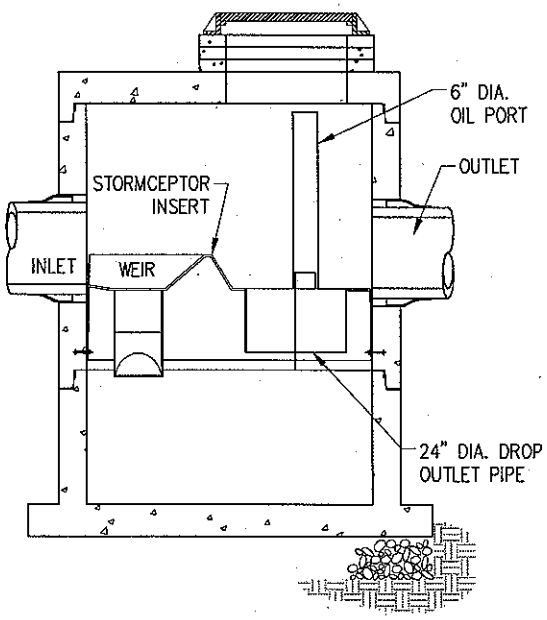
Property Manager: _____

Inspected By: _____

Date of Inspection: _____

Stormceptor Inspected: _____

	Acceptable	Needs Work	Notes



Date of Cleaning: _____ By Whom: _____

Date of Repair: _____ By Whom: _____

Note any discrepancies and suggested corrective actions:

_____

_____

_____

_____

_____

_____

SUBSURFACE INFILTRATION CULTEC SYSTEM INSPECTION FORM

Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Owner: _____

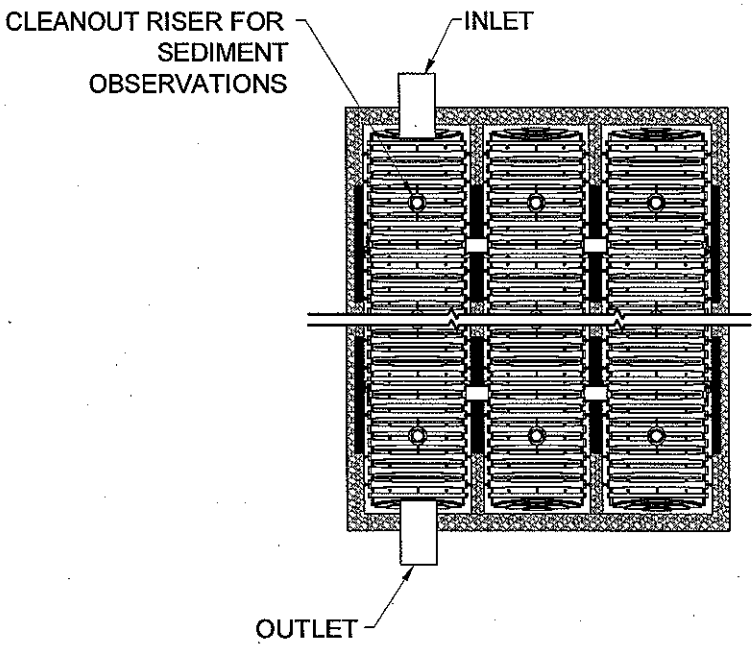
Property Manager: _____

Inspected By: _____

Date of Inspection: _____

System Inspected: _____

	Acceptable	Needs Work	Notes



Date of Cleaning: _____ By Whom: _____

Date of Repair: _____ By Whom: _____

Note any discrepancies and suggested corrective actions:

_____

_____

_____

_____

_____

_____

FLARED END OUTLET INSPECTION FORM

Needham Mews
692 & 744 Greendale Avenue
Needham, Massachusetts

Owner: _____

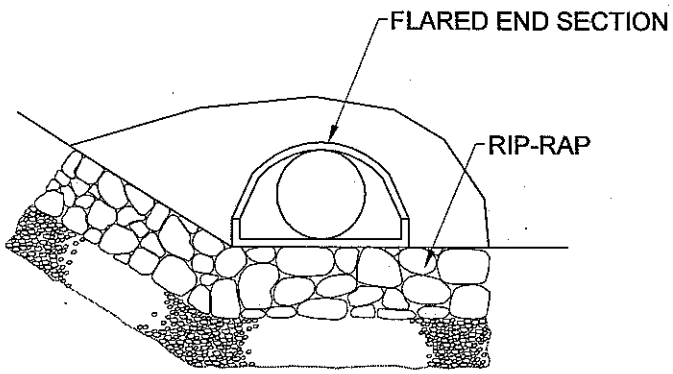
Property Manager: _____

Inspected By: _____

Date of Inspection: _____

Flared End Section Inspected: _____

	Acceptable	Needs Work	Notes



Date of Cleaning: _____ By Whom: _____

Date of Repair: _____ By Whom: _____

Note any discrepancies and suggested corrective actions:

_____

_____

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_____

_____

Appendix G

Soil Evaluation Logs

Commonwealth of Massachusetts
City/Town of Needham

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

A. Facility Information

Greendale Avenue Venture LLC
Owner Name

692 & 744 Greendale Ave — Map 18, Parcels 42, 43, 44
Street Address — Map/Lot #

Needham — MA — 02492
City — State — Zip Code

B. Site Information

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

2. Published Soil Survey Available? ☒ Yes ☐ No If yes: 1989 (Year Published) ____ (Publication Scale) 245B, 254B (Soil Map Unit)
   245B Hinckley sandy loam, 3 to 8 percent slopes
   254B Merrimac fine sandy loam, 3 to 8 percent slopes
   Soil Limitations: none

3. Surficial Geological Report Available? ☐ Yes ☒ No If yes: ____ (Year Published) ____ (Publication Scale) ____ (Map Unit)
   Geologic Material: sand and gravel
   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): 2/2013 (Month/Year) Range: ☒ Above Normal ☐ Normal ☐ Below Normal

7. Other references reviewed: ____

Commonwealth of Massachusetts
City/Town of Needham

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

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

Deep Observation Hole Number: A, B, C & D | 2/26/2013 (Date) | 8 am to 1:30 pm (Time) | P. Sunny to Sunny, 34-42 degrees (Weather)

1. Location

   Ground Elevation at Surface of Hole: see plan Location (identify on plan): _____

2. Land Use: woodland (e.g., woodland, agricultural field, vacant lot, etc.) | few (Surface Stones) | 3-8% (Slope (%))

   mostly pines, oaks, maples (Vegetation) | outwash terrace (Landform) | _____ (Position on Landscape (attach sheet))

3. Distances from:

Open Water Body	n/a feet	Drainage Way	>100 feet	Possible Wet Area	n/a feet
Property Line	>20 feet	Drinking Water Well	n/a feet	Other	n/a feet

4. Parent Material: sand and gravel 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: n/a (Depth Weeping from Pit) | n/a (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: see soil logs (inches) | _____ (elevation)

Commonwealth of Massachusetts
City/Town of Needham

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

C. On-Site Review (continued)

Deep Observation Hole Number: TP A (elev. 124)

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			
0-8	A	10YR3/2				sandy loam					
8-24	B	10YR5/6				loamy sand					
24-125	C	2.5Y5/4	100"	fairly distinct		gravelly coars sand	20%	40%	single grain	loose	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham

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

C. On-Site Review (continued)

Deep Observation Hole Number: TP B (elev. 129.5)

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			
0-12	A	10YR3/2				sandy loam					
12-24	B	10YR5/6				loamy sand					
24-108	C	2.5Y5/4	96"	faint gray		gravelly coars sand	30%	50%	single grain	loose	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham

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

D. Determination of High Groundwater Elevation

1. Method Used:

	A.	B.
☐ Depth observed standing water in observation hole	inches	inches
☐ Depth weeping from side of observation hole	inches	inches
☒ Depth to soil redoximorphic features (mottles)	A. TP A: 100" (el. 115.7) inches	B. TP B: 96" (el. 121.5) 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: 24 inches Lower boundary: 108 inches

Commonwealth of Massachusetts
City/Town of Needham

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

C. On-Site Review (continued)

Deep Observation Hole Number: TP C (elev. 130)

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	A	10YR3/2				sandy loam					
10-24	B	10YR5/6				loamy sand					
24-96	C	2.5Y5/4	no mottles			gravelly coars sand	50%	50%	single grain	loose	
96	R					ledge					

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham

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

C. On-Site Review (continued)

Deep Observation Hole Number: TP D (elev. 134)

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			
0-8	A	10YR3/2				sandy loam					
8-24	B	10YR5/6				loamy sand					
24-48	C1	2.5Y6/4				gravelly coars sand	25%	10%	single grain	loose	
48-115	C2	2.5Y5/4	no mottles			gravelly coars sand	50%	30%	single grain	loose	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham

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

D. Determination of High Groundwater Elevation

1. Method Used:

	A.	B.
☐ Depth observed standing water in observation hole	inches	inches
☐ Depth weeping from side of observation hole	A. inches	B. inches
☒ Depth to soil redoximorphic features (mottles)	A. TP C: >96" (el. 122.0) inches	B. TP D: >115" (el. 124.4) inches
☐ Groundwater adjustment (USGS methodology)	A. inches	B. inches

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

_____ (Adjustment Factor) _____ (Adjusted Groundwater Level)

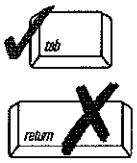
E. Depth of Pervious Material

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: 24 inches Lower boundary: 96 inches

Commonwealth of Massachusetts
City/Town of Needham
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

Greendale Avenue Venture LLC
Owner Name

692 & 744 Greendale Avenue
Street Address or Lot #

Needham	MA	02492
City/Town	State	Zip Code

Glenn K. Dougherty, P.E., SE# 607	(508) 903-2312
Contact Person (if different from Owner)	Telephone Number

B. Test Results

	2/26/2013 Date	9:20 am Time	2/26/2013 Date	10:49 am Time
Observation Hole #	TP A		TP C	
Depth of Perc	36" below grade (elev 121.0)		36" below grade (elev 127.0)	
Start Pre-Soak	9:20		10:49	
End Pre-Soak	9:28		10:59	
Time at 12"	9:29		11:00	
Time at 9"	9:35		11:06	
Time at 6"	9:41		11:15	
Time (9"-6")	6		9	
Rate (Min./Inch)	2 min./in.		3 min./in.	
	Test Passed: ☒ Test Failed: ☐		Test Passed: ☒ Test Failed: ☐	

Glenn K. Dougherty, P.E., SE# 607
Test Performed By:

Witnessed By:

Comments:

Commonwealth of Massachusetts
City/Town of Needham

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

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

Deep Observation Hole Number: E, F, G & H | 2/28/2013 (Date) | 9 am to 1 pm (Time) | M. Cloudy, 32-38 degrees (Weather)

1. Location

   Ground Elevation at Surface of Hole: see plan Location (identify on plan): _____

2. Land Use: woodland (e.g., woodland, agricultural field, vacant lot, etc.) | few (Surface Stones) | 3-8% (Slope (%))

   mostly pines, oaks, maples (Vegetation) | outwash terrace (Landform) | _____ (Position on Landscape (attach sheet))

3. Distances from:

Open Water Body	n/a feet	Drainage Way	>100 feet	Possible Wet Area	n/a feet
Property Line	>20 feet	Drinking Water Well	n/a feet	Other	n/a feet

4. Parent Material: sand and gravel 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: n/a (Depth Weeping from Pit) | n/a (Depth Standing Water in Hole)

   Estimated Depth to High Groundwater: see soil logs (inches) | _____ (elevation)

Commonwealth of Massachusetts
City/Town of Needham

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

C. On-Site Review (continued)

Deep Observation Hole Number: TP E (elev. 111)

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			
0-16	A	10YR3/2				fine sandy loam					
16-36	B	10YR5/6				fine sandy loam					
36-144	C	10YR6/4	no mottles			clean coars sand	15%	0%	single grain	loose	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham

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

C. On-Site Review (continued)

Deep Observation Hole Number: TP F (elev. 110.5)

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			
0-16	A	10YR3/2				fine sandy loam					
16-42	B	10YR5/6				fine sandy loam					
42-138	C	2.5Y6/4	no mottles			clean coars sand	15%	0%	single grain	loose	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham

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

D. Determination of High Groundwater Elevation

1. Method Used:

	A.	B.
☐ Depth observed standing water in observation hole	inches	inches
☐ Depth weeping from side of observation hole	inches	inches
☒ Depth to soil redoximorphic features (mottles)	A. TP E: >144" (el. 99.0) inches	B. TP F: >138" (el. 99.0) 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: 42 inches Lower boundary: 138 inches

Commonwealth of Massachusetts
City/Town of Needham

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

C. On-Site Review (continued)

Deep Observation Hole Number: TP G (elev. 110)

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			
0-16	A	10YR3/2				sandy loam					
16-36	B	10YR5/6				loamy sand					
36-80	C1	10YR6/4				gravelly coars sand	30%	25%	single grain	loose	
80-136	C2	10YR6/3	no mottles			gravelly coars sand	50%	35%	single grain	loose	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP H (elev. 109)

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			
0-14	A	10YR3/2				fine sandy loam					
14-32	B	10YR5/6				fine sandy loam					
32-72	C1	10YR6/4				gravelly coars sand	25%	10%	single grain	loose	
72-114	C2	10YR6/3	no mottles			hard pan gravl sand	35%	10%	single grain	firm in hole loose out	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Needham

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

D. Determination of High Groundwater Elevation

1. Method Used:

	A.	B.
☐ Depth observed standing water in observation hole	A. inches	B. inches
☐ Depth weeping from side of observation hole	A. inches	B. inches
☒ Depth to soil redoximorphic features (mottles)	A. TP G: >136" (el. 98.7) inches	B. TP H: >114" (el. 99.5) inches
☐ Groundwater adjustment (USGS methodology)	A. inches	B. inches

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

_____ (Adjustment Factor) _____ (Adjusted Groundwater Level)

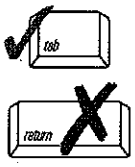
E. Depth of Pervious Material

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: 36 inches Lower boundary: 114 inches

Commonwealth of Massachusetts
City/Town of Needham
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

Greendale Avenue Venture LLC
Owner Name

692 & 744 Greendale Avenue
Street Address or Lot #

Needham	MA	02492
City/Town	State	Zip Code

Glenn K. Dougherty, P.E., SE# 607	(508) 903-2312
Contact Person (if different from Owner)	Telephone Number

B. Test Results

	2/26/2013 Date	12:35 pm Time	2/28/2013 Date	9:27 am Time
Observation Hole #	TP E		TP G	
Depth of Perc	48" below grade (elev 107.0)		48" below grade (elev 106.0)	
Start Pre-Soak	12:35		9:27	
End Pre-Soak	12:43		9:36	
Time at 12"	12:48		9:37	
Time at 9"	12:52		9:40	
Time at 6"	12:56		9:43	
Time (9"-6")	4		3	
Rate (Min./Inch)	< 2 min./in.		< 2 min./in.	
	Test Passed: ☒ Test Failed: ☐		Test Passed: ☒ Test Failed: ☐	

Glenn K. Dougherty, P.E., SE# 607
Test Performed By:

Witnessed By:

Comments:

Commonwealth of Massachusetts
City/Town of Needham
Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

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.

	2/28/2013
Signature of Soil Evaluator	Date
Glenn K. Dougherty, P.E., SE#607	Fall 1998
Typed or Printed Name of Soil Evaluator / License #	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.