"THE BIRCHES"

A 40B RESIDENTIAL PROJECT
OFF LONG RIDGE ROAD, CARLISLE, MASSACHUSETTS

FINAL

STORMWATER MANAGEMENT REPORT

VOLUME 1 OF 2

STORMWATER MANAGEMENT DESIGN

July 1, 2014

PREPARED FOR:

LIFETIME GREEN HOMES, LLC
142 LITTLETON ROAD, WESTFORD, MA 01886

PREPARED BY:
MEISNER BREM CORPORATION
142 LITTLETON ROAD, STE. 16
WESTFORD, MA 01886

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THE BIRCHES
STORMWATER MANAGEMENT REPORT – VOLUME 1 OF 2
A 40B RESIDENTIAL PROJECT OFF LONG RIDGE ROAD, CARLISLE, MA

THE FOLLOWING REPORT HAS BEEN PREPARED UNDER THE SUPERVISION OF A REGISTERED PROFESSIONAL ENGINEER LICENSED IN THE COMMONWEALTH OF MASSACHUSETTS.

"THE BIRCHES"

OFF LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

Volume 1

STORMWATER MANAGEMENT DESIGN

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STORMWATER CHECKLIST

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SECTION 1.0 INTRODUCTION

The following Stormwater Management Report outlines the proposed drainage design, the analysis of the pre and post development stormwater conditions, the design of the structural and non-structural drainage components, the proposed stormwater mitigate strategies for change in cover and proposed impervious area, compliance with Massachusetts Department of Environmental Affairs (MassDEP) Stormwater Handbook, and other related stormwater issues of the development of the project. It also is intended to satisfy the state and local regulations and requirements to protect the surrounding neighborhoods, the natural resources, the existing drainage utilities, and the waters of the Commonwealth from adverse impacts resulting from the stormwater runoff.

Pursuant to the definitions and requirements of a project proposed under MGL Chapter 40B, the project proponent is required to provide preliminary drawings and computations only as changes are typical for these types of projects. However, due to various concerns raised this report is intended to be a Final Stormwater Management Report with the accompanying set of plans.

This program defines a program for controlling, conveying, treating and discharging the stormwater runoff from the site in accordance with the adopted MassDEP *Stormwater Handbook, the Federal and State Clean Water Acts, the Wetlands Protection Act, the Coastal Zone Act, a portion of the National Pollutant Discharge Elimination System Program and the Town of Carlisle Subdivision of Land Regulations.*

The report identifies by means of narratives, calculations, plans and specifications that suitable and appropriate quantity and quality control measures have been provided to gather, control, treat, and discharge stormwater runoff. The storm frequencies analyzed are the 2 yr, 10 yr, 25 yr, and 100 yr pursuant to MassDEP and local regulations. A summary tabulation of the pre development and post development peak flow rates is provided.

Low Impact Development (LID) and Best Management Practices (BMP) concepts and designs are utilized in accordance with MassDEP guidelines as shown herein and on the Plans.

This stormwater analysis includes a quantity comparison of the pre-developed flows to the post-developed flows to assure that no increase in the rate of runoff at the property boundaries. The design includes the totality of LID practices, BMP's, and Stormwater Management Facilities (SMF's) to control the discharge flow rate from the site at a rate no greater than the existing pre-developed flow rate. This Report also discusses the design for the water quality treatment methods and evaluates the compliance to the various codes, regulations, and policies.

THE BIRCHES

STORMWATER MANAGEMENT REPORT – VOLUME 1 OF 2
A 40B RESIDENTIAL PROJECT OFF LONG RIDGE ROAD, CARLISLE, MA

This report includes:

- i) discussion of the project area: existing and proposed,
- ii) various record maps and plans
- iii) overview discussion of stormwater management design
- iv) full analysis of the Pre vs. Post Development conditions,
- v) division of the land into SubCatchment Areas,
- vi) computation of the weighted average "CN" for each SubCatchment area,
- vii) computation of the time of concentrations for each SubCatchment area,
- viii) grades of stormwater components from the Plan & Profile and Grading plan of the site, rain gardens, bio-retention area and all other developed areas
- ix) final HydroCAD report with all subcatchment areas, pipe sizes, types, slopes, and invert elevations, treatment systems, rain gardens, bio-retention area, and infiltration areas.
- x) sizing and details of the rain gardens, bio-retentioan area, and infiltration system.
- xi) manufacturers cut sheet for the infiltration chambers and "stormwater buffer zone" proprietary products
- xii) summary of pre vs post development flow rates
- xiii) discussion of LID and BMP
- xiv) LID credit
- xv) computations of provided vs. required recharge
- xvi) computations of provided water quality volume vs. required water quality volume
- xvii) operation and maintenance manual

The full plan set entitled Residential Site Plan Set, "The Birches", Carlisle, MA prepared for Lifetime Green Homes, LLC, 142 Littleton Road, Westford, MA by Meisner Brem Corporation, dated November 14, 2014 consisting of 12 sheets (Plans), is hereby incorporated herein by reference.

SECTION 2.0 GENERAL PROJECT INFORMATION -

SECTION 2.1 GENERAL

The proposed residential project is a 20 unit, single family housing project proposed under Massachusetts General Law (MGL) Chapter 40B off Long Ridge Road in Carlisle, Massachusetts. The parcel area is 9.84 acres. The property is currently used as a residential single family home and horse stables and riding arena - with outside boarders - as an exempted farm over 5 acres. The existing home will be remodeled as one of the homes in the project. A new 24 foot wide private driveway (private driveway) will provide access to the homes.

SECTION 2.2 EXISTING CONDITIONS

2.2.1 Site

The project is located at 100 Long Ridge Road in Carlisle, Massachusetts and consists of 9.84 acres of land. It is currently used as one existing residential dwelling constructed about 1974 by Deck House, Inc. and horse farm.

About 4 ½ acres of the property presently cleared with the balance as woodland. The timber is primarily a mix of large eastern white pines and pin oaks with lesser quantities of other high canopy species such as hemlock, maple, and birch.

The topography throughout the property ranges a total of approximately 30 feet (from minimum to maximum) but a large portion near the house and barn is fairly level . Most of the other areas have a modest slope and a few select, smaller areas are quite steep.

Soil testing throughout the property indicate a well drained soil with percolation rates of 2-5 minutes per inch with depths to the seasonal high water table ranging from 24” to 84”. In summary, the soils are very good and will certainly support septic system(s).

The property abuts the Blood Farm Trail which connects to Estabrook Woods and other conservation open space areas and trails totaling over 900 acres of land used frequently by many members of the community.

The property has been improved by the addition of a 6 stall, 2 story barn with tack room, feed room, and hay storage. In addition, the property includes several dirt paddocks, grass paddocks, and grass turn-out areas (fields) as outdoor spaces on the farm for the horses. A manure pile conforming to the regulations of the Carlisle Board of Health is maintained regularly.

Currently, all the stormwater runoff from this site flows easterly or southerly on the property and then easterly to the intermittent stream which then flows easterly until it crosses Nowell Farme Road and eventually River Road to the Concord River to the east.

2.2.2 Geology

The topography ranges from a relative low of about elevation 80 at the far east of the site to a high point at about elevation 126 at the northwestern corner and adjacent to the Blood Trail. More than half of the area of development is fairly flat with a sloping area to the easterly sections.

The soils are generally fairly well draining glacial till but veins of sand have been observed. In addition rock outcroppings are noticeable along the intermittent stream in areas that are not proposed for development.

For more information on soil types, especially NCRS soil mapping see Section 2.3.

2.2.4 Wetlands

An intermittent stream and narrow wetland system traverses the rear portion of the property flowing southerly and turning easterly in the narrower section of the property. The bordering vegetated wetland associated with this stream is quite narrow and follows within several feet of the streambed to a point about 500 feet to the east where the wetland widens significantly prior to crossing Nowell Farme Road. There is also a potential vernal pool in this most easterly area over 300 feet from the closest proposed development.

At this time the proposed project does not expect to alter any wetland resource areas. Building and disturbance is proposed directly adjacent to the wetland in the buffer zone.

SECTION 2.3 EXISTING SOILS

2.3.1 NRCS Soil Types

The Soil Conservation Service with the United States Department of Agriculture has mapped the project area for soil types. The SCS soils types are now available online at the USDA Natural Resources Conservation Service (NRCS) website. A print-out of the Off Site Soils and On Site Soils is included herein in Section 3.4.

The USDA classifies soils into four (4) hydrologic soil groups as follows:

TABLE 2.3: NRCS - SCS SOIL GROUPS

SCS Soils Group	General Description
A	Sands & Gravels - highly permeable
B	Glacial Till – more permeable
C	Glacial Till – less permeable
D	Impermeable, silts, clays, muck

Group A—Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

Group B—Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

Group C—Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

Group D—Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential. All soils with a depth to a water impermeable layer less than 50 centimeters [20 inches] and all soils with a water table within 60 centimeters [24 inches] of the surface are in this group, although some may have a dual classification, as described in the next section, if they can be adequately drained.[1]

[1] Part 630, Hydrology, National Engineering Handbook, Chapter 7, Hydrology by United States Department of Agriculture, Natural Resources Conservation Service, 2007 (210-V1-NEH, May, 2007)

The soils on the site consist of soils within Hydrologic Soil Groups B, C, and D. However, the NCRS map is obviously incorrect in some locations as clearly noted by the wetland survey. Therefore, the Woodbridge soil is extrapolated to most all of the developed area. Woodbridge is within the Soil Hydological Group C.

SECTION 2.4 PROPOSED DEVELOPMENT

The project proposes 20 units, including the existing home, at a density of 2.03 units per acre. The homes will be single family with two car garages and three bedrooms totaling an average of about 2500 square feet of living space. Approximately seven of the nineteen new homes will have walk out basements as the site grades allow. Each house will be designed with a usable front porch sited 20’ to 30’ from the edge of the road to encourage lot owners to socialize with their neighbors regularly. The land between the porch and private driveway will be landscaped with formal rain garden and other aesthetic garden areas; not just green lawn. These garden areas will be maintained by the Condominium Truat and will enhance the view as one drives through the project. The outdoor spaces in the rear will be the typical patio, deck, and screened porch for more private entertaining.

The layout of the proposed private driveway begins opposite, and over 100 feet east of, the existing intersection of Garnet Rock Lane and Long Ridge Road. The private driveway is curvilinear and traverses a gentle grade for 500 feet to a sharp right curve downhill to a cul-de-sac turnaround feature. The proposed private driveway width includes a traveled way to match the existing roadways with a paved 24 foot travelled way. The private driveway width and cul-de-sac will be designed for the maneuvering of fire apparatus and will be landscaped in the middle with a stormwater feature underground.

Stormwater controls will utilize the principles of Low Impact Development (LID) design wherever feasible. LID strives to mimic nature in reducing runoff by limiting disturbed areas where possible, infiltrating runoff as close to the original point of contact as possible, developing rain gardens to aid in infiltrating the lower storm intensities, and designing sustainable best management practices to address concentrated runoff to mitigate the impact to the groundwater, wetland, and receiving waters.

Electricity service is currently by NStar via underground wires and surface mounted transformers. This project will extend the electrical service, in kind. The site is also serviced for cable television by Comcast™, also underground. Domestic water service will be provided by shared, private wells with the required legal restrictions, easements, and use agreements. Sewerage will be by three separate shared systems and will utilize Alternative Technologies (MassDEP approved state of the art components). Water supply for fire suppression will be provided by the proposed 30,000 gallon fiberglass fire cistern. Homeownership documents will allow for the assessment of fees to maintain the sewerage, drainage, and water systems as well as the private driveways, utilities, and open space areas, etc. The primary heat source is still being investigated to provide the most efficient design and includes propane, oil, and heat pumps as alternatives being considered. Natural gas is not available in the street system. Solid waste will be as all other residences in Carlisle – to the Transfer Station.

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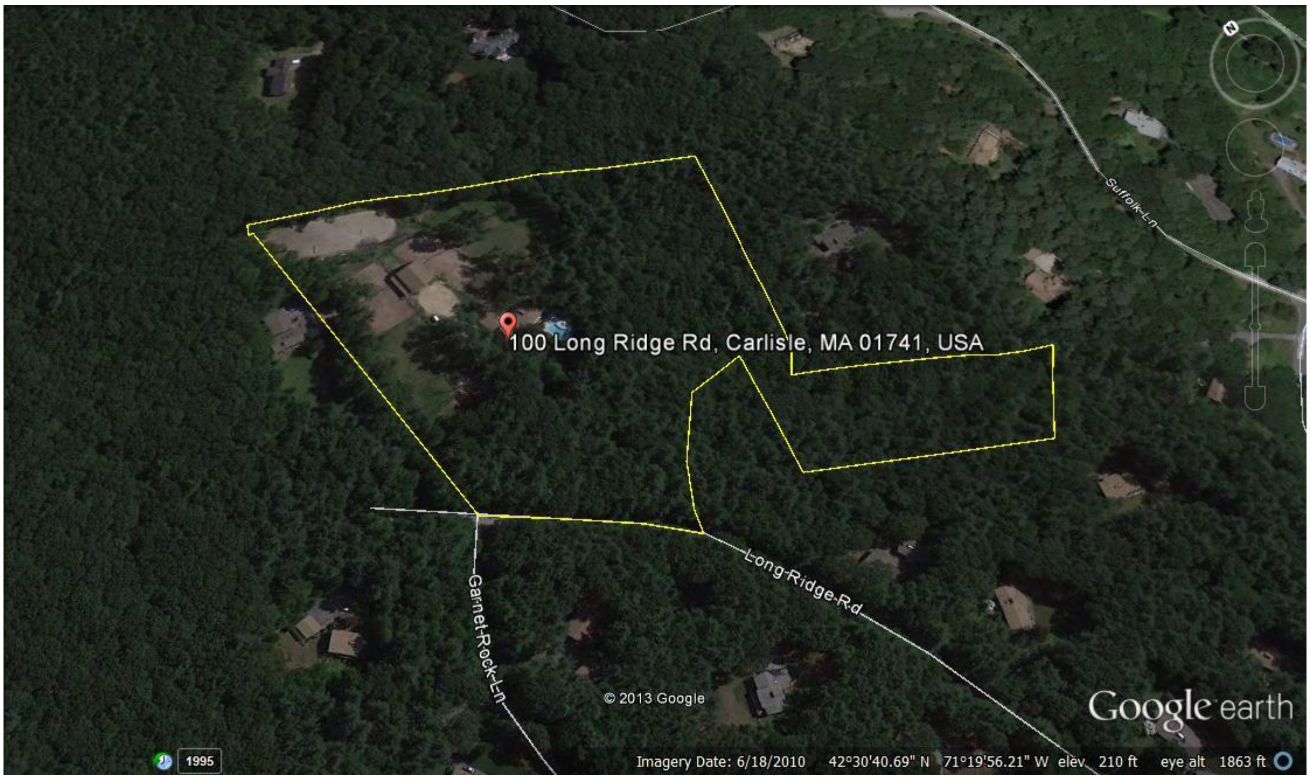
Section 3.0 Maps

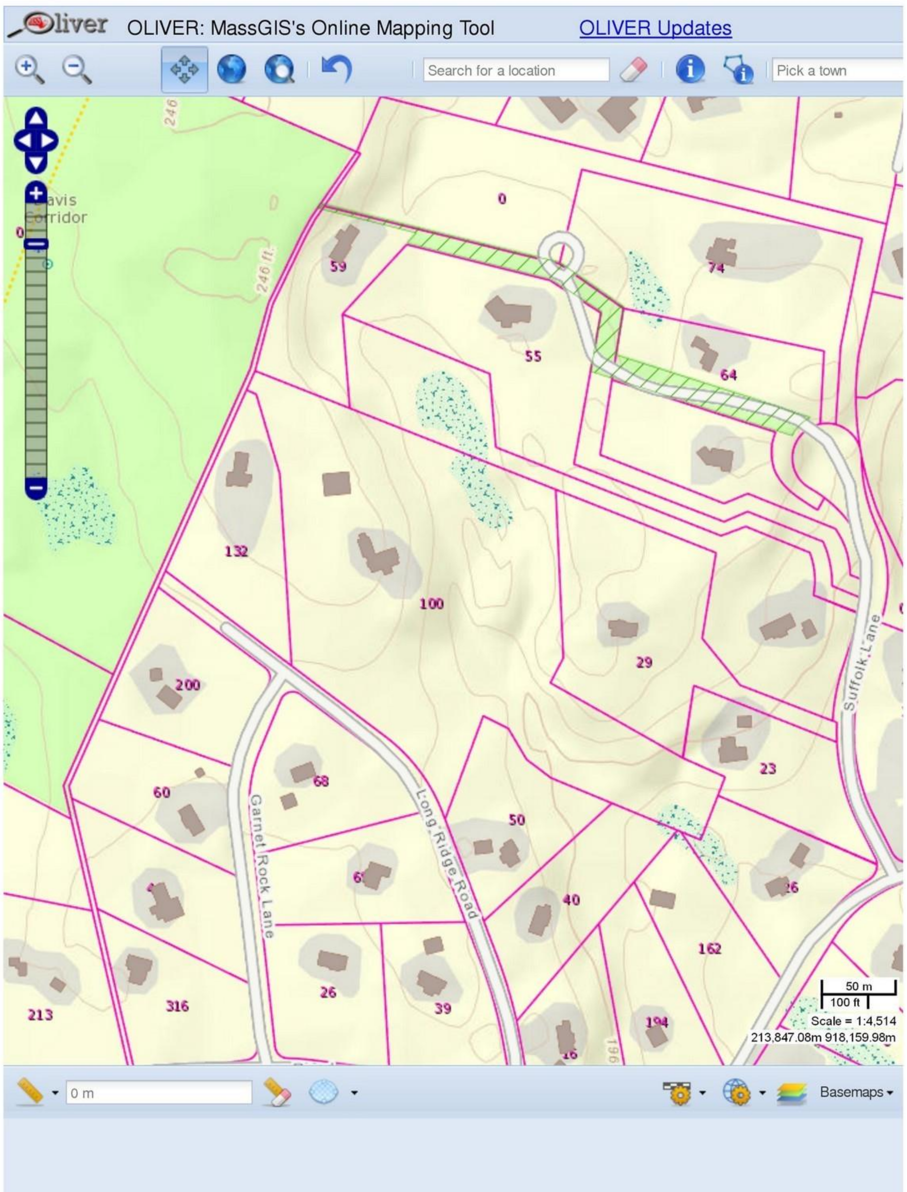
SECTION 3.1 SITE LOCUS / GOOGLE EARTH MAP

FIGURE 3.1 NOT TO SCALE



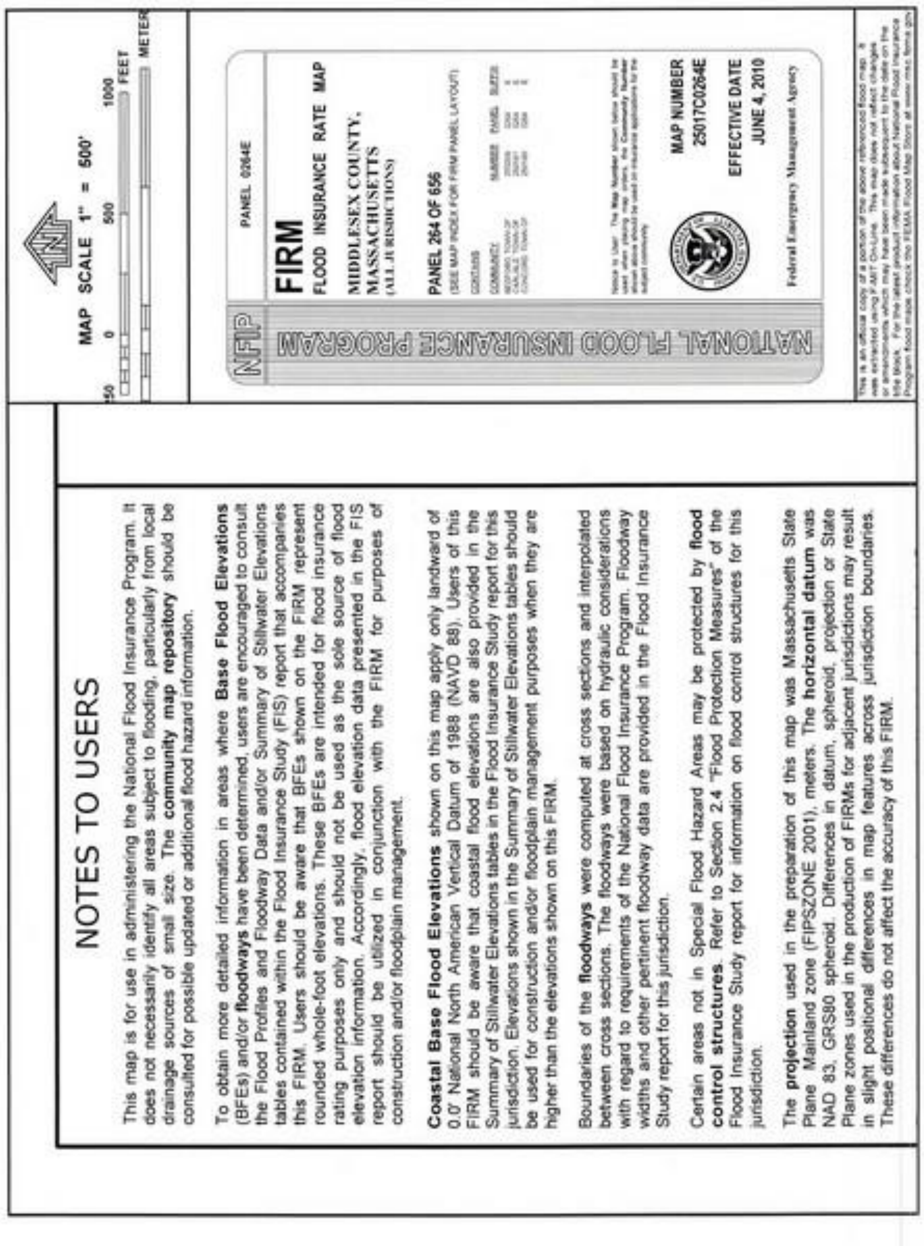
SECTION 3.2 MASS GIS MAP

FIGURE 3.2 NOT TO SCALE



3.3 FLOOD INSURANCE RATE MAP (FIRM)

FIGURE 3.3 COMMUNITY PANEL: 250176 0264 E
MAP DATE: JUNE 4, 2010



NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' National North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations tables in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations tables should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Massachusetts State Plane Mainland zone (FIPSZONE 2001), meters. The **horizontal datum** was NAD 83, GRS80 spheroid. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

MAP SCALE 1" = 500'
250 0 500 1000 FEET
METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0264E

FIRM
FLOOD INSURANCE RATE MAP

MIDDLESEX COUNTY, MASSACHUSETTS
(ALL JURISDICTIONS)

PANEL 264 OF 656
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

MAP NUMBER
25017C0264E

EFFECTIVE DATE
JUNE 4, 2010

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov

SECTION 3.4 SOILS MAP

FIGURE 3.4 ON SITE SOILS: SCALE: AS SHOWN

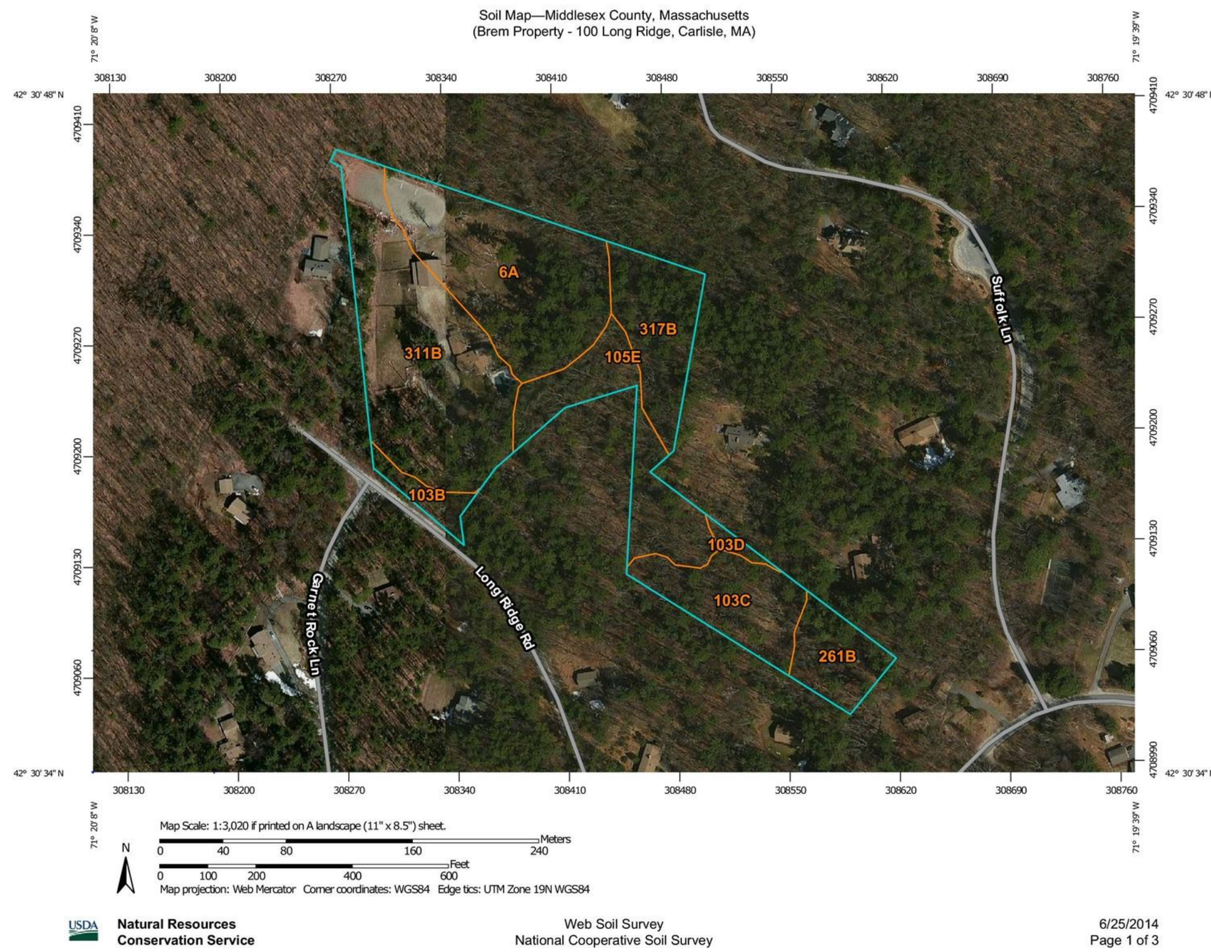


FIGURE 3.5 SOILS MAP LEGEND

Soil Map—Middlesex County, Massachusetts
(Brem Property - 100 Long Ridge, Carlisle, MA)

MAP LEGEND

Area of Interest (AOI)
Area of Interest (AOI)
Soils
Soil Map Unit Polygons
Soil Map Unit Lines
Soil Map Unit Points
Special Point Features
Blowout
Borrow Pit
Clay Spot
Closed Depression
Gravel Pit
Gravelly Spot
Landfill
Lava Flow
Marsh or swamp
Mine or Quarry
Miscellaneous Water
Perennial Water
Rock Outcrop
Saline Spot
Sandy Spot
Severely Eroded Spot
Sinkhole
Slide or Slip
Sodic Spot
Spoil Area
Stony Spot
Very Stony Spot
Wet Spot
Other
Special Line Features
Water Features
Streams and Canals
Transportation
Rails
Interstate Highways
US Routes
Major Roads
Local Roads
Background
Aerial Photography

MAP INFORMATION

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

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

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

Soil Survey Area: Middlesex County, Massachusetts
Survey Area Data: Version 13, Dec 17, 2013

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 30, 2011—May 1, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

USDA Natural Resources Conservation Service — Web Soil Survey, National Cooperative Soil Survey — 6/25/2014, Page 2 of 3

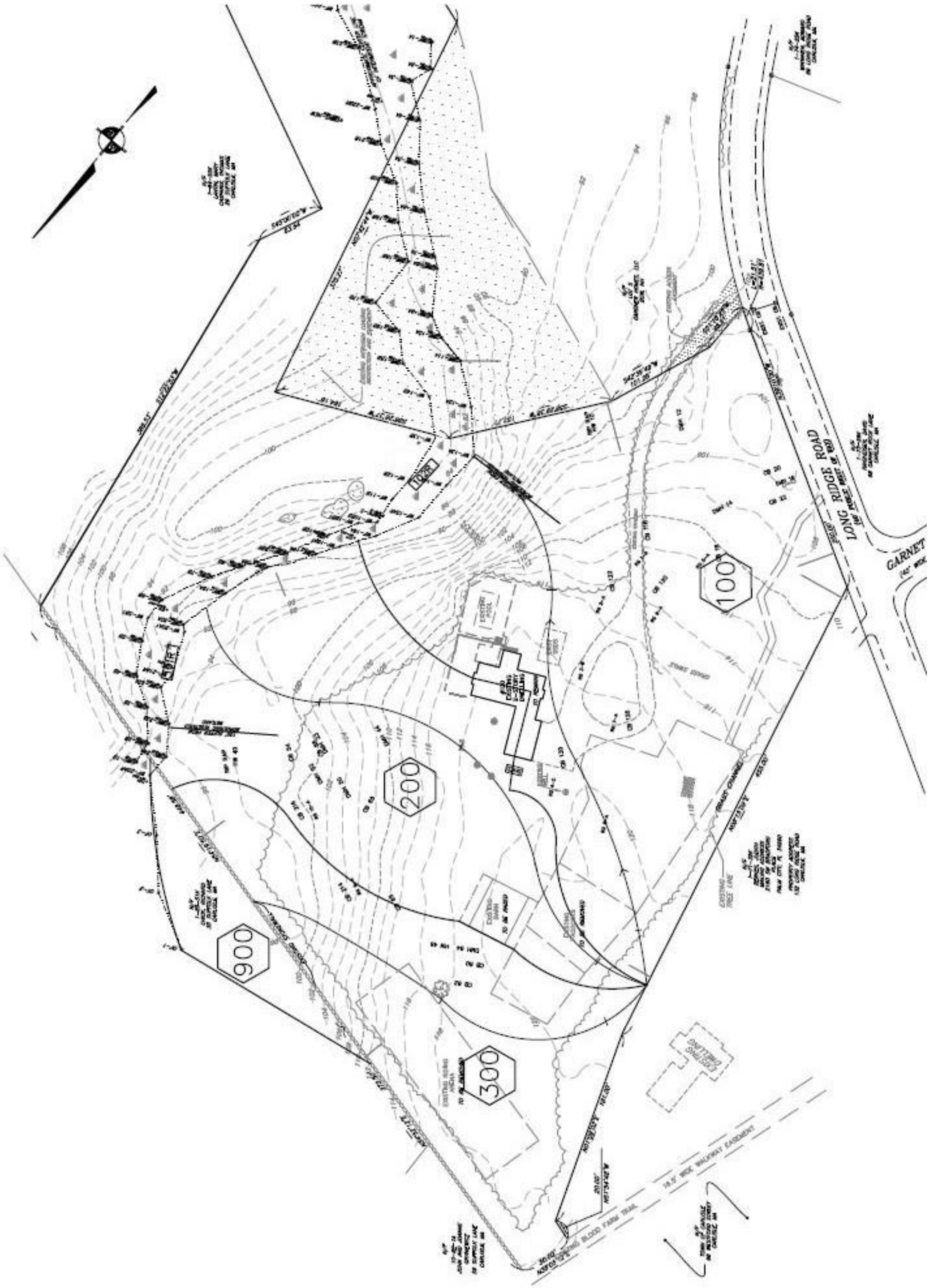
FIGURE 3.6: SOILS HYDROLOGIC SOIL GROUP AND SITE COVERAGE (% OF AOI)

Soil Map—Middlesex County, Massachusetts — Brem Property - 100 Long Ridge, Carlisle, MA

Map Unit Legend

Middlesex County, Massachusetts (MA017)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
6A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	2.6	24.7%
103B	Charlton-Hollis-Rock outcrop complex, 3 to 8 percent slopes	0.3	2.6%
103C	Charlton-Hollis-Rock outcrop complex, 8 to 15 percent slopes	1.1	10.5%
103D	Charlton-Hollis-Rock outcrop complex, 15 to 25 percent slopes	0.1	0.9%
105E	Rock outcrop-Hollis complex, 3 to 35 percent slopes	1.4	13.2%
261B	Tisbury silt loam, 3 to 8 percent slopes	0.7	6.6%
311B	Woodbridge fine sandy loam, 3 to 8 percent slopes, very stony	3.3	30.7%
317B	Scituate fine sandy loam, 3 to 8 percent slopes, extremely stony	1.1	10.7%
Totals for Area of Interest		**10.6**	**100.0%**

SECTION 3.5 DRAINAGE AREA MAPS – PRE DEVELOPMENT



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A 40B RESIDENTIAL PROJECT OFF LONG RIDGE ROAD, CARLISLE, MA

SECTION 3.6 DRAINAGE AREA MAPS – POST DEVELOPMENT

Section 4.0 Stormwater Management Overview

SECTION 4.1 STORMWATER MANAGEMENT PLAN – DEFINITION AND GOALS

4.1.1 Definition

A *Stormwater Management Plan* is a program for controlling, conveying, treating and discharging stormwater runoff. It is a system intended to protect the surrounding neighborhoods, the existing drainage facilities, and the waters of the Commonwealth of Massachusetts from adverse impacts caused by stormwater runoff. The plan consists of engineering designs including drawings, details and specifications of construction, narratives, and supporting calculations to justify the feasibility to construct and comply with the requirements of the adopted MassDEP *Stormwater Handbook, the Federal and State Clean Water Acts, the Wetlands Protection Act, the Coastal Zone Act, a portion of the National Pollutant Discharge Elimination System Program and the Town of Carlisle Subdivision of Land Regulations.*

4.1.2 Goal

The goal of a *Stormwater Management Plan* is to provide suitable quantity and quality control measures for stormwater runoff from a developed property compliant with the applicable regulatory standards including the adopted MassDEP *Stormwater Handbook.* It should be simplistic in design, cost effective to construct, and reasonable to maintain. The design should blend into the natural features and site resources and take full advantage of existing environmental mechanisms to accomplish any necessary mitigation. The primary intention of the adopted MassDEP *Stormwater Handbook* is to provide the guidance for the selection, implementation and operation and management of such systems.

SECTION 4.2 UNDERSTANDING RUNOFF AND STORMWATER MANAGEMENT

4.2.1 Hydrologic Cycle

The basis of stormwater management begins with the understanding of the natural mechanisms of the earth's ecosystems. This requires the knowledge of the hydrologic cycle that generates the runoff that in turn creates the rivers, ponds and wetlands we are so familiar with. These surface features are the primary source for the recharge of the subsurface aquifers. Development or the construction of man-made features alters these natural cycles and their performances. The key to good management of the altered circumstances is to know and understand, then imitate the natural mechanisms, controlling the stormwater runoff in much the same way that nature does. This is also a key component of Low Impact Development, mirroring nature by limiting the changed environment, recharging as close as possible to the location of each raindrop, and using natural, sustainable structures where necessary with as little impact as possible.

The hydrologic cycle describes the simplistic logical mechanisms of water within the earth's ecosystems. It is a representation of the equilibrium that is constantly balancing the status of water affected by the variations in the seasons, temperatures, weather and rainfall. It also is affected by both natural and man-made impacts to the ecosystem. The cycle is presented as three basic steps:

> **PRECIPITATION**: consisting of rain, snow, hail, sleet, fog or mist.
>
> **COLLECTION and INFILTRATION**: representative of the precipitation converting to runoff, concentrating into surface drainage features such as rivers, creeks, lakes, ponds, and wetlands. A portion of this will infiltrate into the soils, percolating downward to recharge the groundwater and contribute to the subsurface aquifers.
>
> **EVAPORATION and TRANSPIRATION:** the process of vaporizing the water fluid to return it to the atmosphere, by means of thermally evaporating the surface waters, or via the vegetation uptake and natural release through the leaves.[2]

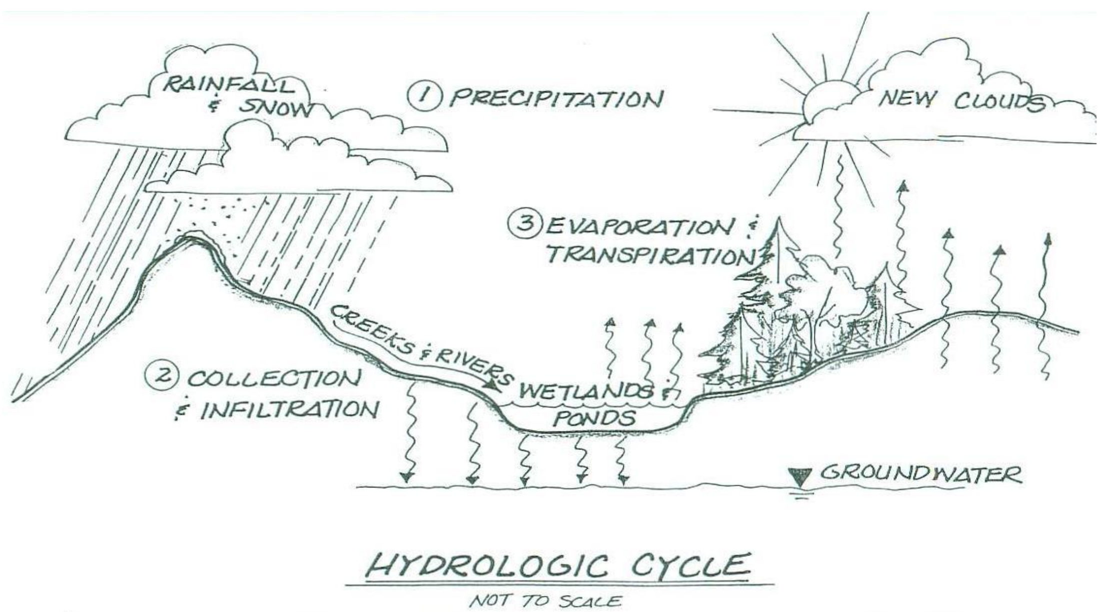


Figure 4.1

2 Excerpted from: "*Managing Stormwater in Massachusetts*", Volume Two: Best Management Practices (BMP) Manual, dated March 1997

After understanding the role water plays in the earth's ecosystem, the next focus is on the localized features that effect the generation of the runoff. This will aid in predicting the quantities, the quality and the character of the flows.

4.2.2 Stormwater Runoff

Runoff, or surface water movement, is a result of the COLLECTION and INFILTRATION stage of the hydrologic cycle. The volume, speed and character of the runoff flow is dependent on the size of the precipitation event (i.e. the amount of water in a given time period) and the conditions of the land. As the precipitation contacts the surface, the runoff generated is dependent on the contributing area size, shape, topography, soils, antecedent moisture content from previous precipitation including snowmelt, vegetative coverage, and drainage features. These items, in conjunction with man-made features, directly affect the water's movements.

<u>4.2.2.1 Contributing Area</u>

The contributing area establishes the boundary limits for the waters movement. It is the relationship between the topographic features and the physics of gravitational forces. Simply put, as the precipitation falls to the surface, it runs downhill from the highest point. The boundary limits represent the highest established elevations within the "lay of the land", i.e.; the break lines between the basin areas, much like the peak of a roofline, directing the flow in a direction of the lower elevations. The contributing area size is a factor directly correlating the total runoff volume to the available collection surface. The area shape is a function of its consistency or homogeneous nature established by the topography and land features (e.g. a sharp valley with a wide flat floodplain, vs. a long rolling meadows with multiple intermittent drainage channels which will potentially generate two completely different runoff flow regimes).

<u>4.2.2.2 Topography</u>

The topography not only defines the contributing area, but also has a major effect on the rate of runoff, the peak discharge, velocity and the resulting soil erosion potential, and other flow characteristics. The slope differential, or total change in elevation, quantifies the physical vertical drop through the flow travel path length (drop per length, rise/run), used in calculating the runoff velocity (length traveled per time period, feet per second) and thus the travel time (Tc).

The velocity is a result of the concentration of flows that in turn define the creation of the drainage features. The flow velocities are a factor in the energy force behind surface weathering and wear related to erosional factors that develop streambeds and channels. The lack of significant velocity is evident in the ponded areas such as lakes and wetlands. When the velocities increase, the flow regime has the ability to move materials of heavier weight (suspended solids). As it slows the heavier particles separate out and drop to the bottom. The end result is erosion or sedimentation. The velocity changes not only with the slope, but is directly related to the size of the precipitation event, the smoothness of the channel surface (roughness coefficient, n), the cross-sectional geometry, and the depth of flow in the channel bed which is a function of the flow rate (Q).

4.2.2.3 Soils

Soil properties influence the process of the generation of the runoff from rainfall. The major effect of soils to runoff is on the volume of runoff generated as the remnant flow of the soils' ability to percolate, or infiltrate the precipitation contacting it. The type of soil regulates the overall capacity and ability over time to absorb runoff. For example, a clay matrix of soil may percolate a large portion of the beginning precipitation, but as the material quickly reaches a saturation point, it swells, stopping the ability of the runoff to infiltrate into the soil, thus generating a higher level of runoff. On the other hand, a clean sand or gravel matrix could potentially infiltrate all the runoff indefinitely, minimizing surface runoff. The effect of the soils on the runoff estimation calculations is represented as one component of the *"runoff curve number" (CN).* Soils are categorized in one of four generalized groupings, "A","B","C", and "D", ranging from a high infiltration – low runoff "A" type (sand), to a low infiltration – high runoff "D" type (clay or muck).

Infiltration into the different soil horizons (layers) offers water quality treatment by filtration, adsorption, absorption and biochemical breakdown of pollutants. Some soils offer better removal capacities for specific pollutants than others do. The organic topsoil has a tremendous ability to collect and breakdown organic and hydrocarbon compounds. This is due to the composition of the materials similar to compost (breaking down of the foliage, litter and debris), in an environment rich in aerobic (presence of oxygen) bacteria cultures and free-ion receptor points. As the water infiltrates downward into the anaerobic (lack of oxygen) conditions other chemical reactions that can only occur under those environmental conditions will occur along with the physical act of filtering to remove and breakdown additional pollutants. The type of soil including its chemical composition affects the removal rate based on its ionization capacity. Lastly, soil acts as a physical filter trapping particulates, suspended solids, and pathogens.

In summary, infiltration of rain water through the ground helps to cleanse the water by physical (filtration), chemical (ionic exchange), and biological (bacteria) processes.

4.2.2.4 Vegetation

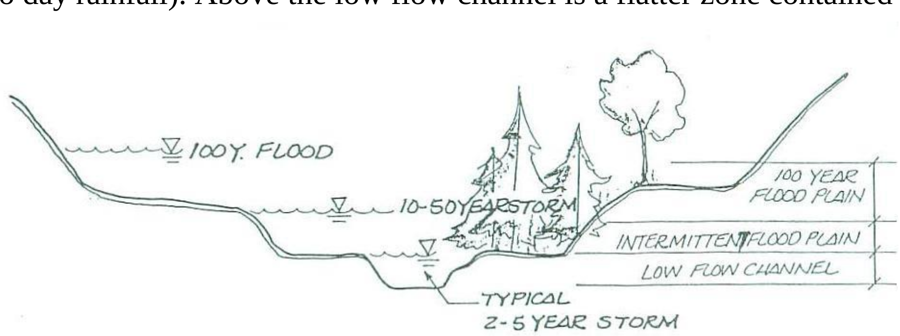
Vegetation affects runoff in several ways. The foliage and its litter maintain the surfaces' ability to infiltrate by protecting it from compacting and sealing under the impacts of precipitation. Some of the rainfall is retained on the surfaces of the leaves and evaporates directly back into the atmosphere. Other trapped water is lagged or stored so long prior to contacting the surface and joining the flow regime, that it is insignificant to affecting the peak runoff. Transpiration from the plants takes a portion of the soil moisture and releases it through the leaves as a natural byproduct of their nutrient uptake. The ground cover vegetation, in combination with the ground litter create numerous micro barriers damming the water flow, slowing and detaining it, resulting in an elongated time of concentration. This flow through the vegetation acts as nature's water quality treatment method, "biofiltering", removing pollutants from the flow regime by plant uptake and biological breakdown. The effects of the vegetation or ground surface characteristics on the runoff estimation is represented as the other component of the *"runoff curve number"(CN),* incorporated with the soil type.

4.2.2.5 Drainage Features

The drainage features affect the runoff characteristics by collecting, conveying, storing and distributing the flows according to specific site features and their attributes. These include the intermittent rills, creek beds, channels, streams, lakes, ponds, wetlands, swamps, low points, dams, and any other element, structural, man-made or not, that the runoff must pass through to complete the hydrologic cycle. All stormwater modeling assigns a mathematical input to each element in order to represent the resultant water or runoff flows.

Some elements function to reduce, detain, store or slow the runoff flows, such as ponds, wetlands and swamps. The runoff cycle's flow increases and decreases and are often stored and slowed by the ponding of the larger, flatter areas, buffering the downstream features from damaging excessive flow. Part of the micro-ecosystem characteristic of ponding is their ability to survive the water surface fluctuation caused by the periodic flooding and receding. During low flow periods the stored water is a critical source to support the local fauna and flora and contributing to recharging the subsurface aquifers. These areas also act as natural water quality treatment facilities by allowing for sedimentation, biofilter pollutant uptake within the vegetation, and filtering both through the vegetation and the soils.

Other elements increase the flows and the related velocities, such as creeks, rivers and drainage channels. These features are the conduits for which to transport the runoff and, by virtue of what they are, tend to collect and concentrate the flows, increasing the speed as they go. Since the velocity is a result of the slope, the channel section and roughness coefficient, the natural site characteristics such as the topography, soils, vegetation and ground cover which control those factors. Most drainage channels geometry and capacities are a result of the channel adapting to the natural flow conditions contributing to them. A typical stream cross-section consists of a low flow drainage channel with a capacity to convey the small storm events occurring up to the two year storm frequency (i.e. the typical day to day rainfall). Above the low flow channel is a flatter zone contained



TYPICAL DRAINAGE CHANNEL SECTION
NOT TO SCALE

Figure 4.2

between higher banking, referred to as the intermittent flood plain, with a capacity to flow and store the runoff from the five year to up to fifty year storm events, i.e.; the larger, less occurring, but more damaging events. This zone tends to be vegetated, sometimes heavily, due to the infrequency of flooding, and the availability of water from the low flow channel saturation during the drought periods. The vegetation is beneficial in that it slows the flows with root systems that protect the stream channel from erosion. An additional elevated bench to the section is common, and is configured the same, above the intermittent flood plain, and may be commonly referred to as the 100 year floodplain. This is an area that becomes inundated with flooded runoff during extreme rainfalls. It is compounded by the fact that all components of the drainage system are operating beyond capacity, backing the water up into any available storage volume. These events tend to be of uncommon frequency, short lived, but they cause considerable damages.

Finally, total watershed areas and time of concentration are significant factors in the impacts of various storm frequencies. Typically, rivers and large streams will engage in maximum flow many days after the initial or the most intense part of the rainfall event. This is because it takes many hours for the runoff from large watersheds to join with other flows from hundreds of rills and channels, dozens of creeks, tributaries, and streams prior to joining sections of the upstream river, then time for the river to flow downstream for many miles. Therefore, on shorter, intense storms the small drainage area sites near rivers may have little impact on the river's flooding impacts that will be occurring many hours in the future and well after the peak discharges from a specific small site, downstream and near the river. Detaining these small site flows could actually be detrimental by delaying the peak discharge rate to join with the larger watershed peak flows. The topic point being discussed is simply that an individual site's drainage system should be analyzed as part of a whole and not myopically, by each small developed site.

SECTION 4.3 STORMWATER MANAGEMENT DESIGN

Stormwater Management Facilities need to be developed with consideration of a wide range of variables within the clearly defined objective to provide runoff control. Selection of the proper treatment mechanisms for the specific site use and characteristics are the key to successful management.

Generally, stormwater management systems are considered an element of the framework of an overall water resource system for a particular watershed. The designer first evaluates the impacts from a regional perspective, and then narrows the focus to the specific site. As the designer determines the components of the specific site drainage system, various related factors, both regionally and locally are considered, evaluated, incorporated, and detailed into the engineering design.

Stormwater management combines a distinct range of interrelated variables to compose a unified program of action. These are divided into five categories:

1) Design Issues: storm frequencies and intensities, soils, vegetation, groundwater, peak flows, quality treatment, life/safety
2) Regional Issues: climate, watershed/ sub-basin relationship, environmental sensitivity to receiving waters
3) Local Issues: adjacent land use, material specifications and availability, access and construction feasibility
4) Costs: project costs, stormwater management costs, cost/benefit analysis, land availability and value
5) Maintenance: owner/manager of system, responsible entity, expertise, equipment handler, inspection, protection, monitoring

Using these parameters as a guide, the designer evaluates the site conditions, develops a drainage concept, and performs hydrologic and stormwater design and hydraulic calculations to prepare the basis for the plan. The design concept is supported by the hydrologic, hydraulic and modeling / routing calculations, the plan design and details and the material specifications of the drainage system components. After a submittal and approval process with the appropriate authority, the design engineer or municipal engineer should monitor the construction for compliance with the intended design concept of the plans. Site inspections are performed to verify the assumed site conditions and allow for modifications if the conditions vary. Upon completing the construction, the system implementation, performance monitoring, and maintenance phase begins. At this point the day to day operation would be the responsibility of the operating entity. The design engineer should be available to the owner to monitor the system for operational troubleshooting and in-situ modifications as required.

Selection of suitable stormwater management systems is site-specific. All sites are different, this is inherent in stormwater management design. There is no single process or detail that can be used in every instance. All of the previously mentioned design parameters should be reviewed to help in developing the “best design” for a particular site, but note that ultimately each design is customized to the specifics of the runoff and site characteristics. As mentioned previously, the final design is often based on Low Impact Development (LID) techniques or the selection of Best Management Practices (BMP) that have been developed considering all site parameters. All BMP’s must have detailed specifications designed for each site and for each usage within a project.

Above all, throughout the system design and BMP selection process, the final choices should adhere to the following primary goals:

1) Imitate Natural Control Mechanisms
2) Preserve and Utilize the Existing Natural Resources

3) Quantity and Quality control
4) Simple, Long Lasting Design
5) Cost Effective Construction
6) Easy Maintenance

With these concepts in mind, the design engineer determines the best choice for a quality design.

SECTION 4.4 BEST MANAGEMENT PRACTICES (BMP)

Best Management Practices (BMP), for the purposes of stormwater management, are structural, non-structural and managerial techniques that are recognized to be the most effective and practical means to prevent, control and reduce non-point source pollutants from entering receiving waters. They consist of proven engineering designs, source controls, managed facility operations and maintenance, and public education and awareness programs.

Best Management Practices are utilized to prevent and reduce the adverse impacts due to runoff by:

1) Preserving the hydrologic conditions to resemble the pre-developed conditions,
2) Reducing and preventing flooding by managing the peak runoff rates,
3) Treating the discharges prior to entering the receiving water bodies; removing sediments, oils, and other pollutants; "polishing" the runoff,
4) Minimizing erosion and sedimentation,
5) Reducing the total suspended solids and other pollutants; improving the water quality,
6) Protecting the sensitive environments related to the natural resources.

BMP's vary in their intended usage and ability to be adapted to the site conditions. They also offer differing types and degrees of mitigation, sometimes requiring combinations of systems in order to comply with performance standards. It is imperative that the BMP selection process includes the review of the benefits and drawbacks to identify the limitations of the choice.

The most cost efficient, productive and yet simple BMP's are those that are constructed and operate similar to natural systems. The mechanisms of the earth's ecosystems offer examples of the best practices. Surface vegetation acts to control erosion, slow runoff, filter out and biologically uptake pollutants. Creeks and rivers convey flows through channels with a natural capacity to handle runoff. Ponds, lakes and wetland swamps store excessive flows, slowing the runoff allowing for sedimentation and biological pollutant breakdown. All these items contribute to the recharge of the subsurface aquifers. Because of their natural origins, they continually adapt to changes modifying their configurations, balancing the system as a whole.

The best manmade systems are those similar to the existing natural site features, incorporated into the terrain and operated under the same mechanisms. The end product is an aesthetic blend of synthetic facilities melded into the natural landscape, requiring less maintenance, and resulting in better performance.

SECTION 4.5 LOW IMPACT DEVELOPMENT (LID)

Low impact development (LID) is an innovative land development strategy that utilizes man-made stormwater management features in an effort to re-create naturally occurring drainage characteristics.

It is often easiest to visualize LID practices by imagining a drop of water within the rainstorm. In nature, as explained previously, the raindrop can infiltrate into the ground, absorbed within plants and transpired, evaporated, or joins other raindrops as runoff. As runoff, the drop eventually travels over the ground surface, possibly joins up with much larger flows in some sort of conveyance system (pipes, culverts, etc.), flows through wetland systems, brooks, streams, rivers, and ultimately to the ocean. During this travel the raindrop, as runoff, can add to negative features such as soil erosion or flooding. The concept of LID is to start at the beginning of the cycle instead of the end and attempt to eliminate the raindrop as runoff by various techniques, or if it is runoff, to try to control it early on its travel by creating infiltration mechanisms, reducing slopes, extending the travel time, or other design methods to minimize the impact of the runoff.

LID includes primarily three main design principles that will be discussed below.

1. **Maximize the existing vegetative features**. This design principle is generally inherent in most conventional developments as well as LID projects, particularly in residential subdivision proposals. Open space developments which serve to permanently protect larger swaths of open areas such as forested areas, meadows, and wetlands are preferred. The "do nothing" maxim is the first and foremost part of LID. Otherwise, setting aside land as open space, creating no cut zones, minimizing land alteration are all techniques in the planning process which can have a major impact on minimizing runoff.

2. **Minimize pavement**. The separation from typical land development strategy and LID techniques really begins with principle #2. In an effort to provide a more environmentally friendly LID project, typical roadway widths and pavement areas should be minimized. This could involve proposing narrower paved roadway widths than a typical subdivision roadway or even what is required in a municipality's regulations and standards. Often reduced pavement widths require waivers.

   Asphalt or concrete sidewalks should be considered for reduction or elimination altogether. Of course public safety must be maintained in all instances, but on dead-end streets and other minor roadways, in areas that don't connect to existing sidewalk networks, there are opportunities to reduce the proposed impervious surfaces by eliminating sidewalks and/or reducing the required pavement widths.

Porous pavement should also be considered but with the evaluation of a cost / benefit analysis, aesthetics, maintenance, ownership, and use. For example, porous asphalt pavement on standard roadways in New England are often not practical in that regular sanding and salting for winter conditions will shortly seal the pores and render the pavement impervious in a relatively short time period.

3. **Disconnect large drainage area Sub Catchments into smaller, localized runoff areas.** This principle is the largest separation between conventional development projects and LID projects. The goal of this principle is to more closely mirror the naturally occurring runoff characteristics and infiltration processes. Under natural conditions, a portion of the precipitation that falls infiltrates almost immediately, recharging the groundwater at the point of contact with the ground. Once impervious surfaces and other manmade structures are introduced to an area, this precipitation is more likely to runoff to another ground area, and may not recharge the groundwater at all.

   Conventional stormwater mitigation systems collect this increased stormwater runoff from large land areas and conveys it to a concentrated mitigation facility or directly discharges the runoff to a receiving water. While this strategy is effective in minimizing negative impacts due to potential stormwater runoff increases (reduction of flooding), the naturally occurring stormwater runoff characteristics are altered and large, stormwater collection areas are often constructed, usually in areas near wetland resource areas and within wetland buffer zones. These large stormwater management facilities require removal of the existing vegetated areas usually in close proximity to important resource areas (wetlands).

   An LID stormwater management system will more closely match the undeveloped condition by providing stormwater recharge and infiltration areas in close proximity to the precipitation contact point. LID Stormwater Management Facilities will include numerous vegetated collection and infiltration areas that will provide opportunities for the stormwater runoff to seep into the ground throughout the site. Vegetated drainage channels are utilized to convey stormwater to constructed 'rain gardens' designed to disrupt the overland flow and provide areas for groundwater recharge. Proposed buildings are connected to roof drain dry wells or chamber infiltration systems, designed to provide stormwater recharge, especially the smaller, normal storm frequencies. This allows for annual recharge, an important feature that often gets overlooked when stormwater conveyances and mitigation is typically designed.

By providing isolated areas for stormwater recharge and removing roof runoff from the overall stormwater flow, the magnitude of the increased stormwater runoff will be substantially reduced. This in turn, will reduce the required size of the final stormwater management facility (SMF). A smaller SMF within the resource area buffer zone will minimize the impact to the naturally occurring vegetation in the sensitive buffer zone as well as result in larger areas of naturally occurring vegetation (LID principle #1).

The concepts of LID cannot be used 100%, all the time. In steeper areas, areas with higher erosion potential, areas of poor soils, areas requiring intensive development, certain "hotspots", and other site specific or project specific instances, LID concepts are not always directly applicable. This necessary variance is also part of the LID concept: that each site is unique and requires a specific set of goals to be developed with their ensuing design intent following, and not the reverse. LID is more guideline oriented than requirement or code oriented. This is necessary to deal with the many variables of each particular site.

Generally speaking, LID is a reasonable approach to stormwater management using eco-friendly and sustainable solutions to stormwater mitigation. The site design utilizes 'naturally occurring' stormwater design, treatment, and mitigation. Though manmade, the proposed drainage features will generally imitate the natural drainage characteristics found in undeveloped areas. The well designed LID project will attempt to mirror the site's pre-development drainage characteristics to treat, infiltrate and mitigate increased stormwater runoff generally associated with land development projects.

SECTION 4.6 STORMWATER MANAGEMENT OVERVIEW - SUMMARY AND CONCLUSION

Precipitation, whether it occurs as rain or snow, is the primary contributing source of water that **runs off** the surface of a watershed. The kind of soil and type of vegetation have a major controlling effect on the portion of the precipitation that "runs off" or generally known as runoff. The combined effect of the soil and the vegetative cover on the amount of runoff is represented by the runoff Curve Numbers (CN).

The hydrologic cycle is an explanation of how rainfall either infiltrates, transpires, evaporates, or runs off. The runoff component is the primary feature of stormwater management. The concepts of LID and BMP are to mirror nature as much as possible and to design mitigation strategies to have the least impact as possible. Properly designed stormwater management systems serve to minimize the impact of development through designed processes and controls.

Development and drainage improvements, along with the site's topography and shape characteristics are a factor in the rate of runoff. Drainage systems are modeled, both hydrologic and hydraulic, to determine the peak runoff flow rates which are used to predict the impacts due to development and to design a stormwater management system for mitigation.

The stormwater management plan identifies the site parameters and conditions for a designer to take advantage of the mechanisms of the naturally occurring features. With careful planning, many of the natural resources can be left undisturbed benefiting and enhancing the project and yet providing mitigation for the impacts of the development. A quality plan will not only control the flow and provide treatment, but it will also protect the sensitive natural resources.

Lastly, any specific BMP's utilized should be constructed and maintained properly to be fully effective. Often, the maintenance falls onto municipal public works staff, a homeowner's association, or a single homeowner. Also too often, simple maintenance is neglected and eventually affects the systems capacity to properly treat the runoff as designed.

Yet, in the last 30 years, stormwater management has made a huge and positive impact on our environment in developed areas, which should continue with the advent of newer technologies and increased use.

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SECTION 5.0 STORMWATER MANAGEMENT SYSTEM

SECTION 5.1 MASSDEP STORMWATER MANAGEMENT STANDARDS

The proposed Storm Water Management Plan addresses the Storm Water Management Standards that have been developed by MassDEP to protect the waters of the Commonwealth from adverse impacts resulting from storm water runoff. The design is based on concepts and recommendations obtained from various sources and criteria primarily the Massachusetts Stormwater Handbook, http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

The following is a re-printing of the Massachusetts Stormwater Standards

THE STORMWATER MANAGEMENT STANDARDS

1. No new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.
2. Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.
3. Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook.
4. Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This Standard is met when:

   a. Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;

   b. Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and

   c. Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.

5. For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable. If through source control and/or pollution prevention all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use the specific structural stormwater BMPs determined by the Department to be suitable for such uses as provided in the Massachusetts Stormwater Handbook. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.
6. Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook. A discharge is near a critical area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "storm water discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.
7. A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions.
8. A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.
9. A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.
10. All illicit discharges to the stormwater management system are prohibited.[3]

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[3] Massachusetts Stormwater Handbook, Volume 1:
http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

SECTION 5.2 HYDROLOGIC MODEL

5.2.1 Flow Rate Models

Flow rate estimates were predicted utilizing *Guidelines for Soil and Water Conservation in Urbanized Areas of Massachusetts,* dated October 1997, prepared by U.S. National Resources Conservation Service (NRCS) and "Urban Hydrology for Small Watersheds, Technical Release Number 55", dated 1986, prepared by NRCS. The chosen storm type for this area is the TR 55, Type III storm.

Flow estimate calculations were performed using the "HydroCAD v 8.00" (HydroCAD) stormwater computer modeling software. In addition, the facilities are designed in accordance with generally accepted engineering principles and practices, in conformance with all jurisdictional requirements.

5.2.2 Standard 2: No Increase in Post Development Peak Discharge Rates

The purpose of a majority of the Stormwater Management Calculations is an attempt to model the Pre Development vs. Post Development flow rates. This is a critical component of stormwater management outline as Standard 2 and is encapsulated best by again quoting from the MassDEP Stormwater Handbook:

> **Standard 2:** Stormwater management systems shall be designed so that the post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.
>
> To prevent storm damage and downstream and off-site flooding, Standard 2 requires that the post-development peak discharge rate be equal to or less than the pre-development rate from the 2-year and the 10-year 24-hour storms. BMPs that slow runoff rates through storage and gradual release, such as LID techniques, extended dry detention basins, and wet basins, must be provided to meet Standard 2. Where an area is within the 100-year coastal flood plain or land subject to coastal storm flowage, the control of peak discharge rates is usually unnecessary and may be waived.
>
> For projects subject to jurisdiction under the Wetlands Protection Act, the issuing authority relies on TR 20 and 55[4], which are guides for estimating the effects of land use changes on runoff volume and peak rates of discharge published by Natural Resource Conservation Service (NRCS*).* Applicants must calculate runoff rates from pre-existing and post-development conditions. **Measurement of peak discharge rates is calculated at a design point, typically the lowest point of discharge at the downgradient property boundary.** (emphasis added) The topography of the site may require evaluation at more than

[4] NRCS TR 20&55 - http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/Tools_Models/tool_mod.html. See the Hydrology Handbook for Conservation Commissioners, http://www.mass.gov/dep/water/laws/hydrol.pdf.

one design point, if flow leaves the property in more than one direction. An applicant may demonstrate that a feature beyond the property boundary (e.g. culvert) is more appropriate as a design point.[5]

Proponents must also evaluate the impact of peak discharges from the 100-year 24-hour storm. If this evaluation shows that increased off-site flooding will result from peak discharges from the 100-year 24-hour storms, BMPs must also be provided to attenuate these discharges. [6]

5.2.3 Point of Analysis

5.2.3.1 Description of Subject Site – Point of Analysis Determination

It is important to note the underlined portion above (emphasis added) to highlight a critical component in Stormwater Management and Hydrologic Analysis: the Point of Analysis at the downgradient property boundary.

In order to meet Standard 2 to determine the impact from runoff quantity as a result of development it is necessary to hydrologically model the runoff in an undeveloped site condition, pre-development, and then again in a proposed developed condition, post-development. The representative models are run under the critical design storm frequency events to determine the estimated flow rates for the given scenarios. In all instances, the models are run at a determined Point of Analysis, or possibly at multiple Points of Analysis dependent on property lines, grades, and if the site is within more than one primary watershed. This is a critical concept in stormwater management.

The Points of Analysis for this subject property are at one location since the property flows into the intermittent stream at all sub catchment areas.

Point of Analysis A: Wetland easterly at intermittent stream

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[5] The evaluation may show that retaining the 100-year 24-hour storm event is not needed. In some cases, retaining stormwater from the 100-year 24-hour storm event onsite may aggravate downstream impacts, because of the project's location within the watershed and the timing of the release of stormwater.
[6]Massachusetts Stormwater Handbook, Volume 1:
http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

5.2.4 Strategies for Mitigation of Stormwater Runoff

The undeveloped rates (Pre) are compared to the developed rates (Post), resulting in a differential volume representative of the "*increase in peak runoff due to the development*". At such time a set of Best Management Practice (BMP) designs are incorporated to mitigate the increase. In this case the primary BMP structural components for the majority of the changed runoff are the ten proposed rain gardens, the Bio-Retention area, the proprietary product called "Stormwater Buffer Zone", and the infiltration system.

The proposed stormwater management design is incorporated into the proposed post-development HydroCAD model and run under the critical design storm scenarios to determine the operational performance of the system. Discharge volumes, velocities, depth of flows and dissipation spreads are then calculated to verify the impacts to the receiving areas.

The proposed storm water management plan for this project has been developed using Structural and Non-Structural Best Management Practices (BMP's). Specific BMP's for this project are discussed in more detail in Section 5.4.

SECTION 5.3 LOW IMPACT DEVELOPMENT (LID)

5.3.1 LOW IMPACT DEVELOPMENT (LID) DISCUSSION

Low impact development (LID) is an innovative land development strategy that utilizes man-made stormwater management features in an effort to re-create naturally occurring drainage characteristics as detailed in Section 4.5 above.

In this case, LID is employed with i) providing 3.5 acres of unimproved and undisturbed open space, recharge of the nineteen proposed roofs through a collection system of gutters and downspouts and then through an infiltration system of Cultec™ chambers, ten proposed rain gardens along the private driveway, a bio-retention area, and an infiltration discharge system. More information of these techniques are described below in Section 5.4.

5.3.2 ALLOWABLE LID CREDITS

The Massachusetts Stormwater Handbook allows LID CREDITS for projects which meet certain, specific criteria. Three LID CREDITS are available:

CREDIT 1: Environmentally Sensitive Development

CREDIT 2: Rooftop Runoff Directed to Qualified Pervious Area

CREDIT 3: Roadway, Driveway, or Parking Lot Runoff Directed to Qualifying Pervious Area

<u>This project will utilize LID CREDIT 2</u>**.** The Calculations of the Credit Follow.

5.3.3 LID CREDIT 2:

The area of the new homes (19) will be disconnected by gutters, downspouts, and recharge systems on each lot. A LID Credit is allowed to credit for increasing the recharge the potential runoff before it even begins to be runoff, and near the original point where it hits the land surface. This is one of the primary concepts of LID; recharge at or near the point of rainfall. Roof runoff is relatively small in volume, is easy to collect (gutter and downspout system) and is fairly easy to discharge into the ground with a multitude of various devices. For these reasons, LID Credit 2 is often used.

The impact of these small, individual recharge systems will add to the annual recharge of the site for each storm event throughout the year. This is also a major component of LID; that effective recharge is for all or most storm events and not just the larger storms modeled typically modeled in the stormwater report.

As such, LID Credit 2 allows for this credit to be applied on a percentage basis to:

a) The Required Recharge Volume: Rv

b) The Required Water Quality Volume: V_{WQ}

The credits will be applied below with the calculations of each of the required computations as outlined in Mass DEP, Stormwater Handbook, Volume 3, Chapter 1[7].

[7] http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

5.3.4 LID CREDIT 2 – DETERMINATION OF AVAILABLE CREDIT

Total Site Area: 9.84 Acres

Impervious Areas:

a. Road and Driveways: 40,670 square feeet
b. Homes:
   Existing Home 3,400 square feet
   Proposed 19 Homes –2200 sf x 11+ 1600 sf x 8 37,000 square feet - LID CREDIT 2
   TOTAL IMPERVIOUS – A_{IMP} = 81,070 square feet = 1.86 Acres

Without Roof Recharge:
Percent Impervious: 1.86 Acres / 9.84 Acres = 18.9 %

With Roof Recharge:
Percent Impervious: 1.00 Acres / 9.84 Acres = 10.2 %

LID CREDIT: 10.2/18.9 = 54.0%

LID credits are allowed for providing recharge by disconnecting the roof runoff. However, due to the use of roof infiltration devices for all 19 new homes, the computation below will determine if enough recharge is provided by these units to meet the Required Recharge Volume (Rv) without using the LID Credit.

The Roof Runoff Infiltration design is shown on the plan set and is copied below in Figure 7.1 for reference. The concept is simple: gutters will be installed along the edges of the roofs of each dwelling and directed by downspouts and underground roof drain leaders to a two Cultec Recharger 330 units in series surrounded by stone. This system will allow for the direct and continuous infiltration of the clean runoff associated with the residential roofs. This infiltration will occur for most all storm events including the 40 or so storm events that occur in this region each year. The purpose of the infiltration is to provide the annual recharge lost on the site due to paving and other impervious areas.

SECTION 5.4 BEST MANAGEMENT PRACTICES (BMP) AND LOW IMPACT DEVELOPMENT (LID)

5.4.1 Discussion

Best Management Practices are structural and non-structural mitigation components of a stormwater management system designed to treat or detain stormwater runoff.

For the subject site, the following Low Impact Development programs and Best Management Practices are proposed (underlined items have samples provided for information purposes only):

- Significant area of natural, undeveloped area – Open Space B – 3.5 acres (35% of total site) – LID
- <u>Roof Infiltation Systems</u> – LID (See 5.4.4)
- <u>Infiltration Trench</u> – LID and BMP – (See 5.4.4)
- <u>Bio – Retention Facility</u> – LID and BMP – (See 5.4.5)
- <u>Stormwater Buffer Zone</u> – BMP (See 5.4.3)
- Flat roof drain onto lawn prior to entering closed system – LID
- Grassed Swales – BMP
- Discharge over 100 feet from wetland, if possible - LID

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5.4.2 Proprietary Products: Special Catch Basin – "Stormwater Buffer Zone"

The design intends to use a fairly new but tested product called the "Stormwater Buffer Zone", model SBZ 160D, as special catch basins. These special catch basins will be installed at the intersection of the private driveway with Long Ridge Road with two units and at the low point in the cul-de-sac with two units for a total of FOUR STORMWATER BUFFER ZONE UNITS.

The specific Catch Basin unit designation on the plans on the Stormwater Buffer Zone Detail on Sheet 9 are:

CB 20, 22, 54, 56:

> The Stormwater Buffer Zone system is a stormwater treatment unit that combines the treatment mechanisms of both a gravity separator, and staged membrane filter to address fine sediment and particulate-bound phosphorus, metals, and other pollutants. The unit's patented combination of a gross pollutant strainer and treatment skirt is designed capture gross pollutants and floatables. It is compatible with oil absorbent skimmers, and lets sediment fall to the manhole floor where it can be cleaned using vacuum truck or clamshell equipment. The patented geometry of the treatment skirt is designed to detain and stabilize the discharge of pulse type rain events and allow extended filtration time after a storm event. This detention feature is intended to both increase residence time for settling and filtration, and protect stored sediment from resuspension during extreme flows to prevent scour. The geometry of the system routes all stormwater, including extreme flows, to discharge through some level of filtration.[8]

The MASTEP process yields a TSS removal rate of 62.6% for the Stormwater Buffer Zone. This is above the 44% needed for pretreatment prior to discharge to an infiltration trench.

Additional information is provided below from the Stormwater Technology Clearinghouse[8] and on the plans.

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[8] Stormwater Technology Clearinghouse: See http://www.mastep.net/database/sections_display.cfm?recID=944&vID=6

Stormwater Buffer Zone Product Information:

University of Massachusetts **Amherst**   search UMass Go

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Stormwater Buffer Zone :: A product from STORMWATER BUFFER ZONE ::

General Information
Find information on the BMP type, applications and pollutants treated

Cost
Per unit, CFS, and/or lb of pollutant removed

Design Considerations
Installation and maintenance requirements, design methodology, setbacks, capacities, etc.

Site and Environmental Considerations
Storm types, drainage area, soil types, infiltration rate, residuals, secondary impacts, etc.

Performance Evaluation
Summary table of test status, our rating, links to more detailed information, list of test reports

MASTEP Evaluation Summary
This product was evaluated in at least one third-party study. See MASTEP Evaluation Summary.

In Brief:

The Stormwater Buffer Zone system is a stormwater treatment unit that combines the treatment mechanisms of both a gravity separator, and staged membrane filter to address fine sediment and particulate-bound phosphorus, metals, and other pollutants. The unit's patented combination of a gross pollutant strainer and treatment skirt is designed capture gross pollutants and floatables. It is compatible with oil absorbent skimmers, and lets sediment fall to the manhole floor where it can be cleaned using vacuum truck or clamshell equipment. The patented geometry of the treatment skirt is designed to detain and stabilize the discharge of pulse type rain events and allow extended filtration time after a storm event. This detention feature is intended to both increase residence time for settling and filtration, and protect stored sediment from resuspension during extreme flows to prevent scour. The geometry of the system routes all stormwater, including extreme flows, to discharge through some level of filtration.

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THE BIRCHES
STORMWATER MANAGEMENT REPORT – VOLUME 1 OF 2
A 40B RESIDENTIAL PROJECT OFF LONG RIDGE ROAD, CARLISLE, MA

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Design Considerations

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Stormwater Buffer Zone :: A product from STORMWATER BUFFER ZONE ::

Installation requirements:

SBZ units are set by drainage contractor in conjunction with other drainage manholes and piping in accordance with city or state specifications with regard to base and backfill materials, compaction, and other tolerances. Stormwater quality internal parts are installed by precaster prior to delivery. The SBZ system will operate as a high capacity construction phase BMP immediately after included frame and grate are installed.

Maintenance requirements:

Stormwater Buffer Zone is cleaned by removing the street level inlet grate, removing and emptying the StormBrake gross pollutant trash strainer, and then removing material from the manhole sump using the same method and equipment that is used to clean standard catch basins. It is recommended that every maintenance procedure be recorded in the maintenance log for the site regardless of whether the unit is in construction period or post construction period use. Construction Period: Monthly visual inspection, and brushing off, or hosing off of treatment skirt from street level if needed, plus emptying the strainer of leaf litter, etc while removing it to see skirt. Removal of sediment from the manhole by vactor is not needed unless sediment level reaches treatment skirt, but recommended to be annually otherwise during construction period, or at the end of the construction period. Post Construction Period or Permanent Use: Annual inspection, Biannual cleanout(vactoring): Annual Maintenance; (but every four or six months during the first year): to include visual inspection of strainer and treatment skirt, emptying the strainer of leaf litter, trash, etc (all considered solid waste) while removing it to treat skirt, spraying off or brushing off underside of the treatment skirt, inspecting and recording sediment depth in manhole (if inspection is between cleanouts, or the depth prior to cleanout if unit is being vactored).

Design methodology:

The treatment skirts (tent filters) has multiple regions with each region having a nominal flow rate that is higher than an adjacent relatively lower region. The lower regions with a relatively lower nominal flow rate can provide a high degree of filtration for the runoff from small storm events. For larger storm events, as the rate of runoff entering a storm drain catch basin exceeds the rate at which water is filtered through the lower regions with a lower nominal flow rate, the level of water on the inlet side of the filters increases bringing the higher regions with a relatively higher nominal flow rate into operation. These higher regions with a higher nominal flow rate provide less filtration but greater flow capacity than the lower regions with a lower nominal flow rate. As the surface level of the water is rising, the distance between the more turbulent surface level and the volatile silt on the bottom of the catch basin increases and can provide an increasing buffer zone as flow through the overall system increases.

Pretreatment requirements:

N/A

Post treatment requirements:

N/A

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Performance Evaluation

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Stormwater Buffer Zone :: A product from STORMWATER BUFFER ZONE ::

Performance information: (This product was evaluated in at least one third-party study. See MASTEP Evaluation Summary.)

MASTEP has reviewed one laboratory test of this product, performed by Alden Laboratory. Five flow ranges were tested, up to 125% of design flow. Overall removal efficiency was found to be 62.6%, measured as SSC. Re-entrainment tests were also conducted. The unit was found to produce < 4 mg/l re-suspended sediment – essentially, no scour occurred.

Pollutants addressed	Manufacturer's Removal Efficiency claim	Minimum particle size	Tested removal efficiency (*)	Test Data Status (**)	Notes
Suspended sediment concentration	62.6%	-	62.6 %	2	Results obtained in laboratory study, Alden Laboratory
Debris - floatables	-	-	-	0	Unit has a large 850 micron Gross Pollutant Strainer
Debris- sinking	-	-	-	0	Unit has a large 850 micron Gross Pollutant Strainer

* - Pollution removal efficiency evaluated by MASTEP staff based on review of available performance evaluation reports.

** - **1** = sufficient credible data to be able to evaluate pollution removal efficiency claims. **2** = promising studies are underway. **3** = insufficient credible data be able to evaluate claims. **0** = data review not yet conducted.

Test reports: (click on link to view a summary of a test, click on disk icon to download the full report)

Title	Author/ Agency	Date	TARP compliancy	Test protocol compliancy	Documents
Verification Testing of a 4-ft Stormwater Buffer Zone Stormwater Catch Basin Treatment Unit	James Mailloux	10/22/2012	No	-	SBZ Final Report Alden Lab.pdf

Stormwater Buffer Zone Product Information:

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Site and Environmental Considerations

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Stormwater Buffer Zone :: A product from STORMWATER BUFFER ZONE ::

Storm types:

N/A

Drainage area and soil infiltration:

Drainage area	Acceptable soil infiltration rate
N/A	N/A

Soil types:

N/A

Recharge:

SBZ systems can optionally be ported to provide recharge benefits. In a typical application, lower flows are highly filtered and passed to an external recharge system, while higher flows pass through a more coarse filter region and overflow to a normal storm drain. This branching behavior can be modeled in HydroCAD H&H software to calculate the volume of stormwater routed to recharge vs the volume (if any) directed to the normal storm drain. See www.stormwaterbufferzone.com/hydrocad.htm or www.hydrocad.net for details.

Residuals:

Non-hazardous materials residuals	Hazardous materials
N/A	N/A

Secondary environmental impacts:

N/A

Explanations of environmental impacts:

The SBZ's inlet sock prevents mosquito access from the atmosphere above and the treatment skirt prevents migration from outlet pipe, or inlet pipe if it is a retrofit catchbasin connected in series. All unit sizes are manufactured with this trademarked feature called Mosquito Roadblock®.

Stormwater Buffer Zone Product Information:

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Cost

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Stormwater Buffer Zone :: A product from STORMWATER BUFFER ZONE ::

Capital Costs:

Cost method	Pollutant	Design flow range (CFS)	Design pollutant removal efficiency (%)	Mean design influent concentration (PPM)	Cost range	Average cost
cost per unit	not applicable	-	-	-	$4,300 - $4,800	-

Installation and Maintenance Costs:

Installation Costs		Maintenance Costs	
Range	Average	Range	Average
$500 - $600	$800	$50 - $100	$150

Comments:

Includes manhole, frame, and grate.

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5.4.3 Proprietary Products: Infiltration Chambers – Product Information

The Infiltration Trench in the middle of the cul-de-sac proposes to use 36 Cultec 330XL HD units in series as an Infiltration Trench per Stormwater Handbook. The product is proprietary and is specified on the plans.

The following is part of a manufacturing cut sheet for the Cultec Infiltration Product for information purposes only.

Product Information

Stormwater Chambers

Contactor® Series

The Contactor® Chamber series consists of lower profile chambers and are typically used for installations with depth restrictions or when a larger infiltrative area is required. The 12-inch high Contactor® 100HD is the most popular model within this series for stormwater design.

Other models available within the Contactor® series are: Contactor® EZ-24, Contactor® Field Drain C-4, and Contactor® 125. Design information for these models is available upon request.

Recharger® Series

CULTEC's Recharger® series includes higher profile, larger capacity chambers. Sizes range from 18.5" - 32" (470 - 813 mm) high. Chamber capacities vary from 2.65 - 8.679 cu. ft./ft. (0.246 - 0.806 cu. m/m).

The most popular models within this series are the Recharger® 150HD, 280HD, 330XLHD and V8HD.

Alternate model available within the Recharger® series is: Recharger 180HD. Design information for this model is available upon request.

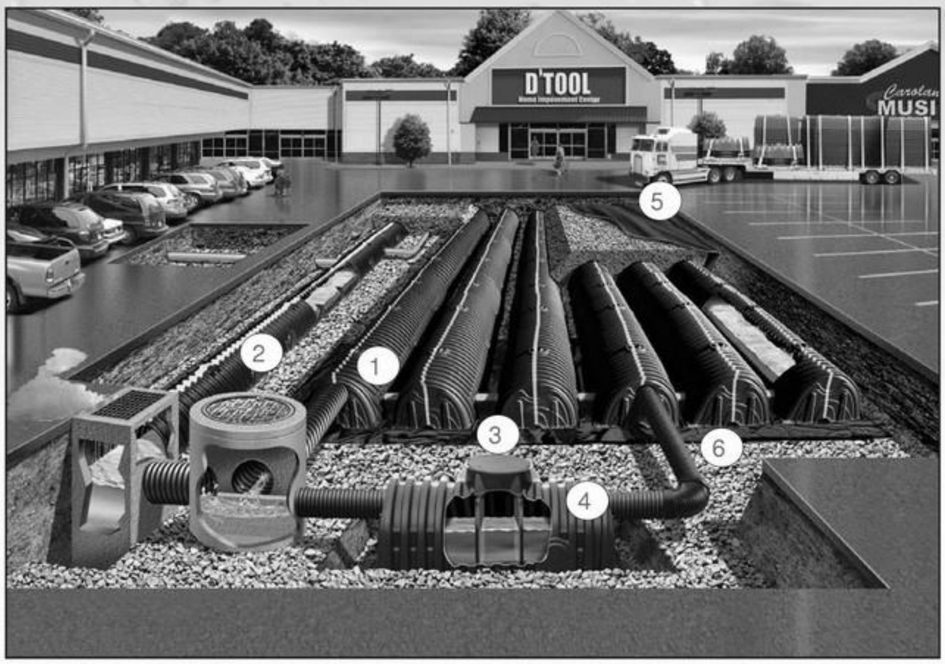
THE BIRCHES

STORMWATER MANAGEMENT REPORT – VOLUME 1 OF 2

A 40B RESIDENTIAL PROJECT OFF LONG RIDGE ROAD, CARLISLE, MA

Product Information

CULTEC



Typical CULTEC Stormwater System Components

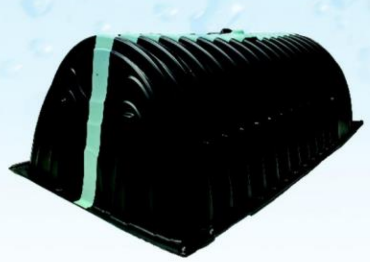
1. CULTEC Stormwater Chamber - used for retention, detention, reclamation
2. CULTEC PAC™ 150 - chamber with bottom used for water conveyance
3. CULTEC HVLV™ Feed Connector - internal manifold component
4. CULTEC StormFilter™ 330 - Water Quality Unit
5. CULTEC No. 410™ Filter Fabric - prevents soil intrusion into system
6. CULTEC No. 20L™ Polyethylene Liner - placed under CULTEC manifold components, prevents scouring
7. CULTEC Warning Tape - Marks off location of underground CULTEC Stormwater System during construction to prevent vehicular traffic
8. Multicade™ Pylon - Marks location of underground CULTEC Stormwater System during construction phase

4

Technical Information

CULTEC Recharger® 330XLHD

The Recharger® 330XLHD is a 30.5" (775 mm) tall, high capacity chamber. Typically when using this model, fewer chambers are required resulting in less labor and a smaller installation area. The Recharger® 330XLHD has the side portal internal manifold feature. HVLV® FC-24 Feed Connectors are inserted into the side portals to create the internal manifold.



Size (L x W x H)	8.5' x 52" x 30.5" 2.59 m x 1321 mm x 775 mm
Installed Length	7' 2.13 m
Length Adjustment per Run	1.50' 0.46 m
Chamber Storage	7.46 ft³/ft 0.69 m³/m 52.21 ft³/unit 1.48 m³/unit
Min. Installed Storage	11.32 ft³/ft 1.05 m³/m 79.26 ft³/unit 2.24 m³/unit
Min. Area Required	33.83 ft² 3.14 m²
Min. Center to Center Spacing	4.83' 1.47 m
Max. Allowable Cover	12' 3.66 m
Max. Inlet Opening in Endwall	24" 600 mm
Side Portal Dimensions (H x W)	10.5" x 12" 267 mm x 305 mm
Max. Allowable Pipe Size in Side Portal	10" 250 mm
Compatible Feed Connector	HVLV® FC-24 Feed Connector

	Stone Foundation Depth		
	6" 152 mm	12" 305 mm	18" 457 mm
Chamber and Stone Storage Per Chamber	79.26 ft³ 2.24 m³	86.03 ft³ 2.44 m³	92.79 ft³ 2.63 m³
Min. Effective Depth	3.54' 1.08 m	4.04' 1.23 m	4.54' 1.38 m
Stone Required Per Chamber	2.50 yd³ 1.91 m³	3.13 yd³ 2.39 m³	3.76 yd³ 2.87 m³

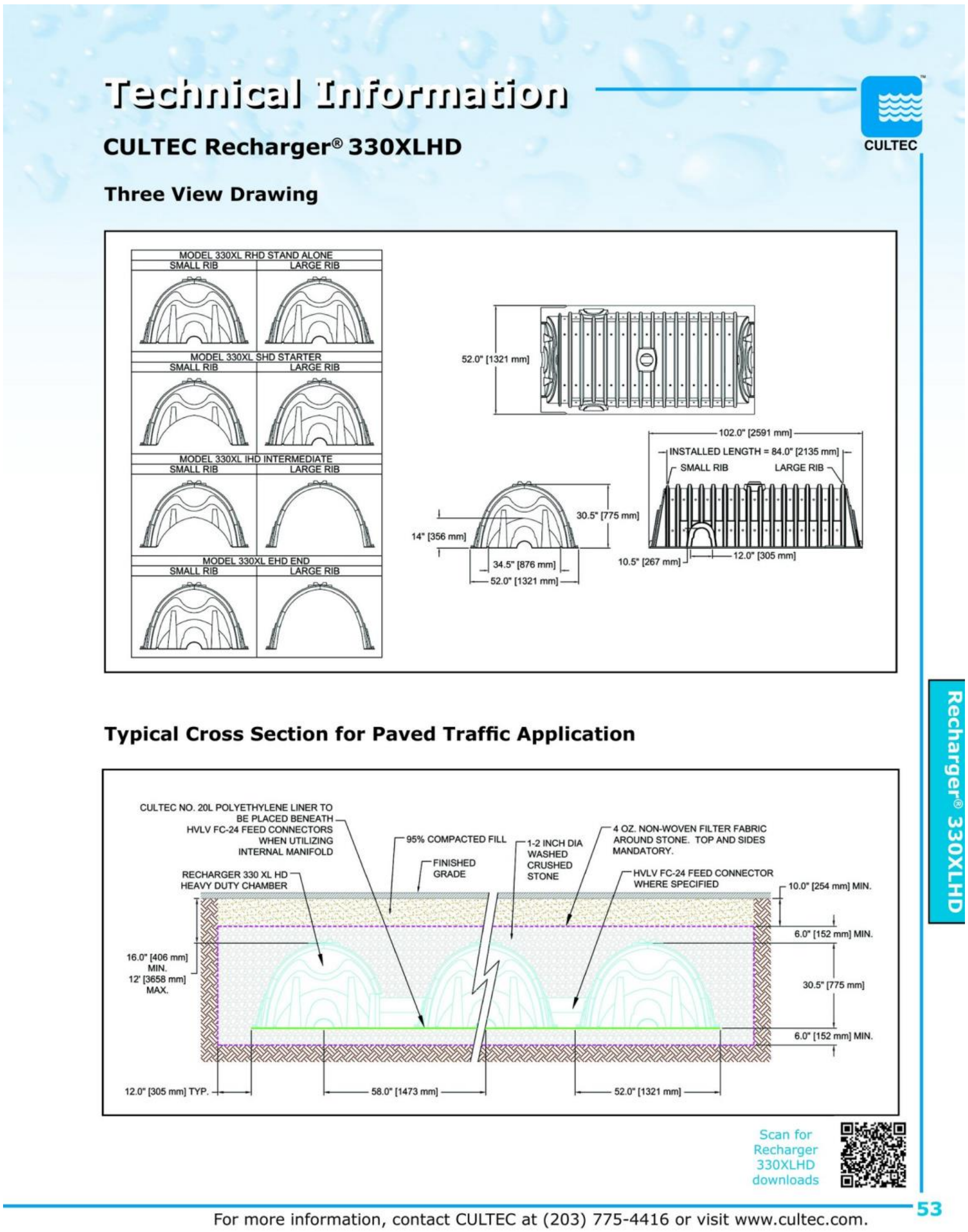
Calculations are based on installed chamber length.
Includes 6" (152 mm) stone above crown of chamber and typical stone surround.
Stone void calculated at 40%.

Recharger® 330XLHD Bare Chamber Storage Volumes

Elevation		Incremental Storage Volume				Cumulative Storage	
in.	mm	ft³/ft	m³/m	ft³	m³	ft³	m³
30.5	775	0.000	0.000	0.000	0.000	52.213	1.479
30	762	0.019	0.002	0.133	0.004	52.213	1.479
29	737	0.051	0.005	0.357	0.010	52.080	1.475
28	711	0.084	0.008	0.588	0.017	51.723	1.465
27	686	0.124	0.012	0.868	0.025	51.135	1.448
26	660	0.150	0.014	1.05	0.030	50.267	1.424
25	635	0.173	0.016	1.211	0.034	49.217	1.394
24	609	0.191	0.018	1.337	0.038	48.006	1.360
23	584	0.207	0.019	1.449	0.041	46.669	1.322
22	559	0.221	0.021	1.547	0.044	45.220	1.281
21	533	0.233	0.022	1.631	0.046	43.673	1.237
20	508	0.244	0.023	1.708	0.048	42.042	1.191
19	483	0.254	0.024	1.778	0.050	40.334	1.142
18	457	0.264	0.025	1.848	0.052	38.556	1.092
17	432	0.271	0.025	1.897	0.054	36.708	1.040
16	406	0.283	0.026	1.981	0.056	34.811	0.986
15	381	0.294	0.027	2.058	0.058	32.830	0.930
14	356	0.296	0.027	2.072	0.059	30.772	0.871
13	330	0.299	0.028	2.093	0.059	28.700	0.813
12	305	0.301	0.028	2.107	0.060	26.607	0.754
11	279	0.303	0.028	2.121	0.060	24.500	0.694
10	254	0.304	0.028	2.128	0.060	22.379	0.634
9	229	0.306	0.028	2.142	0.061	20.251	0.574
8	203	0.313	0.029	2.191	0.062	18.109	0.513
7	178	0.321	0.030	2.247	0.064	15.918	0.451
6	152	0.322	0.030	2.254	0.064	13.671	0.387
5	127	0.323	0.030	2.261	0.064	11.417	0.323
4	102	0.324	0.030	2.268	0.064	9.156	0.259
3	76	0.325	0.030	2.275	0.064	6.888	0.195
2	51	0.327	0.030	2.289	0.065	4.613	0.131
1	25	0.332	0.031	2.324	0.066	2.324	0.066
Total		**7.459**	**0.693**	**52.213**	**1.479**	**52.213**	**1.479**

Calculations are based on installed chamber length.

For more information, contact CULTEC at (203) 775-4416 or visit www.cultec.com.


Technical Information
CULTEC Recharger® 330XLHD
CULTEC
Three View Drawing
MODEL 330XL RHD STAND ALONE
SMALL RIB
LARGE RIB
MODEL 330XL SHD STARTER
SMALL RIB
LARGE RIB
MODEL 330XL IHD INTERMEDIATE
SMALL RIB
LARGE RIB
MODEL 330XL EHD END
SMALL RIB
LARGE RIB
52.0" [1321 mm]
102.0" [2591 mm]
INSTALLED LENGTH = 84.0" [2135 mm]
SMALL RIB
LARGE RIB
30.5" [775 mm]
14" [356 mm]
34.5" [876 mm]
52.0" [1321 mm]
10.5" [267 mm]
12.0" [305 mm]
Typical Cross Section for Paved Traffic Application
CULTEC NO. 20L POLYETHYLENE LINER TO BE PLACED BENEATH HVLV FC-24 FEED CONNECTORS WHEN UTILIZING INTERNAL MANIFOLD
95% COMPACTED FILL
1-2 INCH DIA WASHED CRUSHED STONE
4 OZ. NON-WOVEN FILTER FABRIC AROUND STONE. TOP AND SIDES MANDATORY.
FINISHED GRADE
RECHARGER 330 XL HD HEAVY DUTY CHAMBER
HVLV FC-24 FEED CONNECTOR WHERE SPECIFIED
10.0" [254 mm] MIN.
6.0" [152 mm] MIN.
16.0" [406 mm] MIN.
12' [3658 mm] MAX.
30.5" [775 mm]
6.0" [152 mm] MIN.
12.0" [305 mm] TYP.
58.0" [1473 mm]
52.0" [1321 mm]
Recharger® 330XLHD
Scan for Recharger 330XLHD downloads
For more information, contact CULTEC at (203) 775-4416 or visit www.cultec.com.
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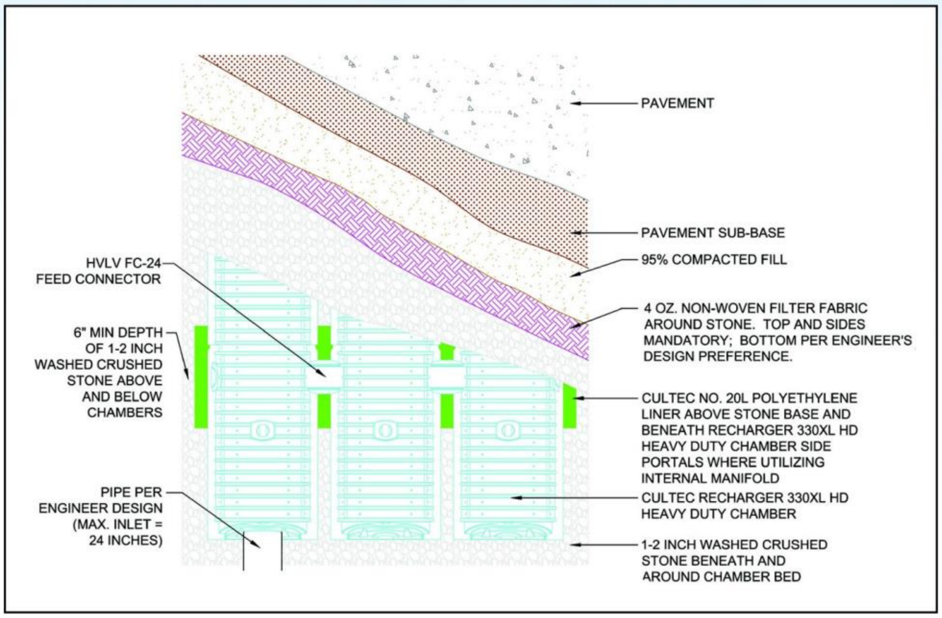
Technical Information

CULTEC Recharger® 330XLHD

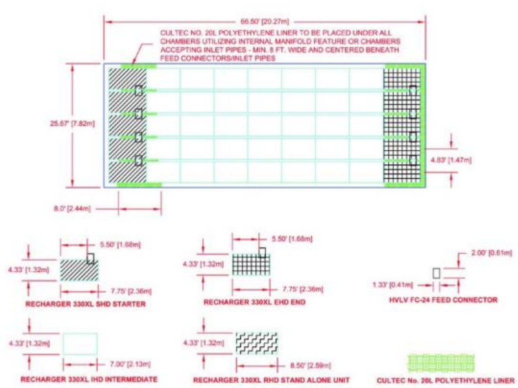
Plan View Drawing



Typical Bed Layout

Using AutoCAD Array Function

1. Add Alternate Units to your Dimension Style and use 0.3048 as the Multiplier
2. Using the Rectangle command, create the three chamber outlines and the feed connectors:
   Starter: 4.33' x 7.75'
   Intermediate: 4.33' x 7.00'
   End: 4.33' x 7.75'
   Feed Connector: 1.33' x 2.00'
3. Hatch the Starter and End chambers to differentiate them. Place a feed connector (as shown) at one end of the starter and end chambers.
4. Select the Intermediate chamber and select the array command.
5. Specify the number of rows and columns (ex. 10 rows, 7 columns). Do not included the starter and end chambers in the column count.
6. The chambers should be oriented horizontally (as shown). Set the row offset to 4.83' and the column offset to 7'. The rotation angle should be 0.
7. Click accept to create the bed.
8. If R-Model chamber is incorporated into the design, use the Rectangle command to create a chamber outline 8.50' x 4.33'. Hatch the R-Model chambers using a unique pattern to differentiate them. Orient the R-Model chamber horizontally, and orient the chambers so there is a .5' spacing between the R-Model and the rest of the chamber rows. Proceed to steps 9 and 10 using the Polyline command instead of the Rectangle command to show the stone border and polyethylene liner. If no R-Model is incorporated into the design, proceed to steps 9 and 10.
9. Using the Rectangle command to surround the bed. Offset the rectangle 1' to represent the stone border.
10. Using the Rectangle command create a polyethylene liner underneath the feed connectors at both ends of the bed. It should be 5 wide and span the width of the bed. Apply correct hatching and label the liner.



Storm Water System Design Aide download available online

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For more information, contact CULTEC at (203) 775-4416 or visit www.cultec.com.

Technical Information

CULTEC

CULTEC Recharger® 330XLHD Specifications

GENERAL

CULTEC Recharger® 330XLHD chambers are designed for underground stormwater management. The chambers may be used for retention, recharging, detention or controlling the flow of on-site stormwater runoff.

CHAMBER PARAMETERS

1. The chambers will be manufactured by CULTEC, Inc. of Brookfield, CT. (203-775-4416 or 1-800-428-5832)
2. The chamber will be vacuum thermoformed of black high molecular weight high density polyethylene (HMWHDPE).
3. The chamber will be arched in shape.
4. The chamber will be open-bottomed.
5. The chamber will be joined using an interlocking overlapping rib method. Connections must be fully shouldered overlapping ribs, having no separate couplings or separate end walls.
6. The nominal chamber dimensions of the CULTEC Recharger® 330XLHD shall be 30.5 inches (775 mm) tall, 52 inches (1321 mm) wide and 8.5 feet (2.59 m) long. The installed length of a joined Recharger® 330XLHD shall be 7 feet (2.13 m).
7. Maximum inlet opening on the chamber endwall is 24 inches (600 mm).
8. The chamber will have two side portals to accept CULTEC HVLV® FC-24 Feed Connectors to create an internal manifold. The nominal dimensions of each side portal will be 10.5 inches (267 mm) high by 12 inches (305 mm) wide. Maximum allowable pipe size in the side portal is 10 inches (250 mm).
9. The nominal chamber dimensions of the CULTEC HVLV® FC-24 Feed Connector shall be 12 inches (305 mm) tall, 16 inches (406 mm) wide and 24.2 inches (614 mm) long.
10. The nominal storage volume of the Recharger® 330XLHD chamber will be 7.459 ft^3 / ft (0.693 m^3 / m) - without stone. The nominal storage volume of a single Recharger® 330XLRHD Stand Alone unit shall be 63.40 ft^3 (1.80 m^3) - without stone. The nominal storage volume of a joined Recharger® 330XLIHD Intermediate unit shall be 52.213 ft^3 (1.478 m^3) - without stone. The nominal storage volume of the length adjustment amount per run shall be 11.19 ft^3 (1.04 m^3) - without stone.
11. The nominal storage volume of the HVLV® FC-24 Feed Connector will be 0.913 ft^3 / ft (0.026 m^3 / m) - without stone.
12. The Recharger® 330XLHD chamber will have fifty-six discharge holes bored into the sidewalls of the unit's core to promote lateral conveyance of water.
13. The Recharger® 330XLHD chamber shall have 16 corrugations.
14. The endwall of the chamber, when present, will be an integral part of the continuously formed unit. Separate end plates cannot be used with this unit.
15. The Recharger® 330XLRHD Stand Alone unit must be formed as a whole chamber having two fully formed integral endwalls and having no separate end plates or separate end walls.
16. The Recharger® 330XLSHD Starter unit must be formed as a whole chamber having one fully formed integral endwall and one partially formed integral endwall with a lower transfer opening of 14 inches (356 mm) high x 34.5 inches (876 mm) wide.
17. The Recharger® 330XLIHD Intermediate unit must be formed as a whole chamber having one fully open endwall and one partially formed integral endwall with a lower transfer opening of 14 inches (356 mm) high x 34.5 inches (876 mm) wide.
18. The Recharger® 330XLEHD End unit must be formed as a whole chamber having one fully formed integral endwall and one fully open end wall and having no separate end plates or end walls.
19. The HVLV® FC-24 Feed Connector must be formed as a whole chamber having two open end walls and having no separate end plates or separate end walls. The unit will fit into the side portals of the Recharger® 330XLHD and act as cross feed connections.
20. Chambers must have horizontal stiffening flex reduction steps between the ribs.
21. Heavy duty units are designated by a colored stripe formed into the part along the length of the chamber.
22. The chamber will have a raised integral cap at the top of the arch in the center of each unit to be used as an optional inspection port or clean-out.
23. The units may be trimmed to custom lengths by cutting back to any corrugation on the large rib end.
24. The chamber shall be manufactured in an ISO 9001:2000 certified facility.
25. Maximum allowable cover over the top of the chamber shall be 12' (3.66 m).
26. The chamber will be designed to withstand traffic loads when installed according to CULTEC's recommended installation instructions.

Recharger® 330XLHD

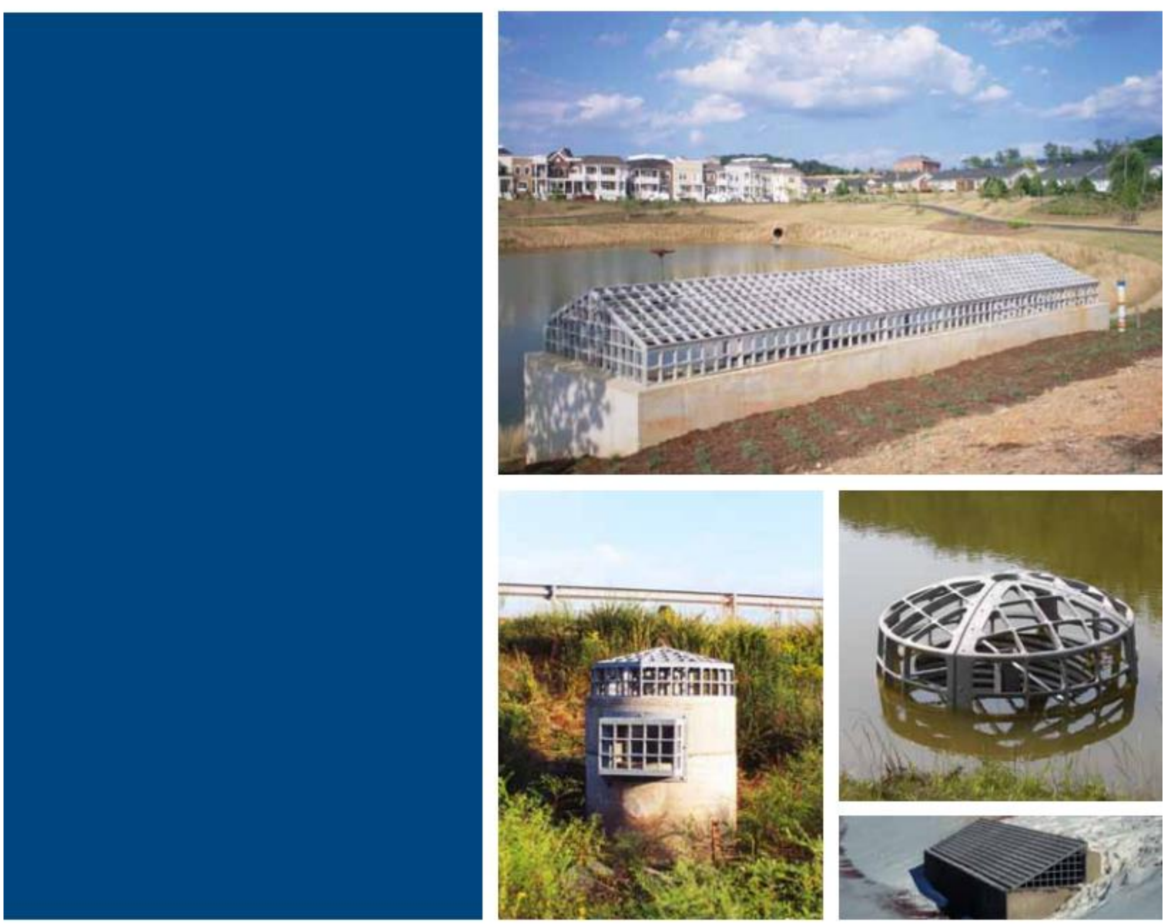
5.4.4 Proprietary Products: Special Catch Basin

The Bioretention area proposes to use a Contech PYDP-24 Pyramid Trash Rack over the riser pipe. The product is proprietary and is specified on the plans.

The following is part of a brochure for the Contech Trash Rack and is for information purposes only.

CONTECH
ENGINEERED SOLUTIONS

Structural HDPE Products for Water Screening



Key Advantages

Availability

Contech® Engineered Solutions is pleased to introduce StormRax,™ its line of structural plastic trash racks and debris cages for stormwater management basins and pond structures from Plastic Solutions Inc. In addition to the full line of standard sizes, we can also customize to fit your specific requirements.

StormRax trash racks are available in numerous sizes and shapes to accommodate nearly every type of application.

Strength & Durability

Structural plastic has a cellular core surrounded by integral skins forming a totally integrated structure. Structural molded parts made from HDPE and fiberglass have a high strength-to-weight ratio and have 3 to 4 times greater rigidity than solid parts of the same material of equal weight.

Racks are designed to withstand the conditions of pond structures - rough handling, high/low temperatures and long term weather exposure. Structural plastic has replaced wood, concrete, solid plastics and metals in a variety of applications.

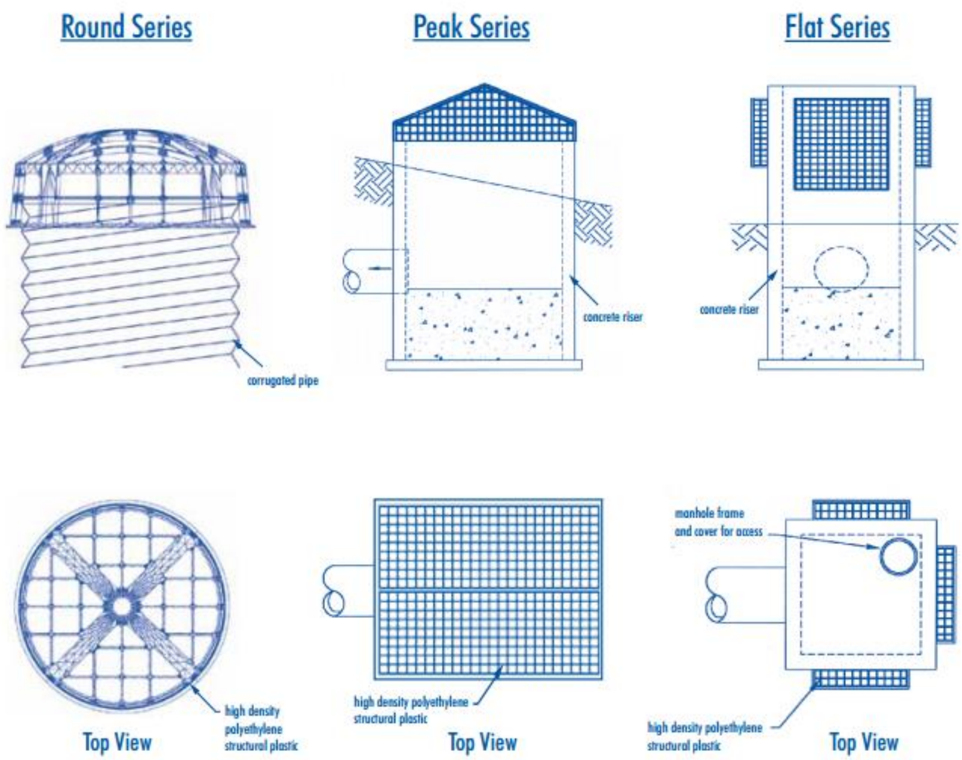
Quality Alternative

Structural plastic racks are a great alternative to painted and galvanized steel racks for use in stormwater management ponds and general water screening. They also provide a structurally sound product with a long lasting quality appearance.

With structural plastic, you can take advantage of the many benefits such as:

- Lighter Weight
- Elimination of Corrosion
- Design Flexibility
- Greater Part Stiffness and Stability
- Chemical Resistance
- Installation Savings

Applications and Options



StormRax pyramid racks are available with an anti-vortex device and racks can be mounted on concrete structures, plastic and metal pipe.

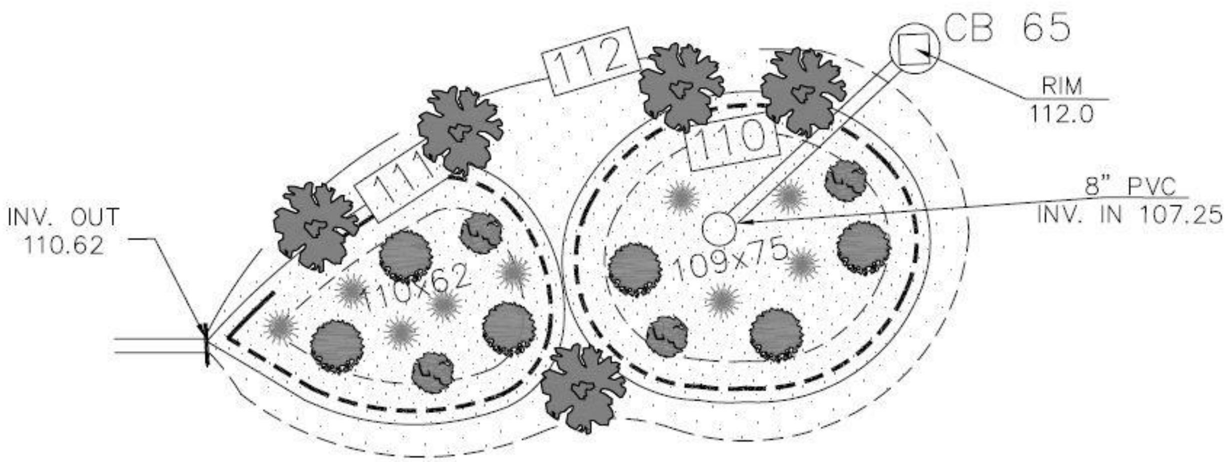
New Modular Design - Improved 'Round Series'

Our newest trash rack evolution is constructed of Structural Foam Molded High Density Polyethylene, a strong and lightweight replacement for steel that has proven to be a durable and economical alternative.

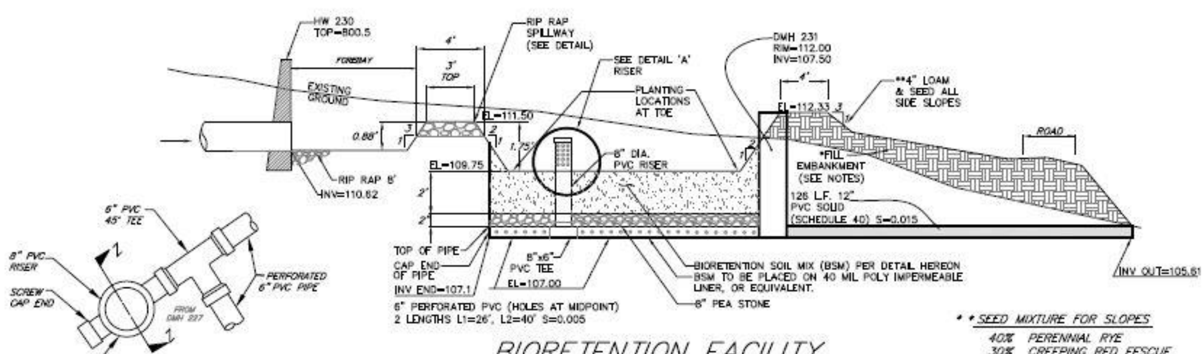
3

5.4.5 Bio – Retention Facility

The following is the design of the bio-retention facility near Unit 18 with a copy of the plan view, a profile view showing the piping, soil mix, planting, and other details of construction.

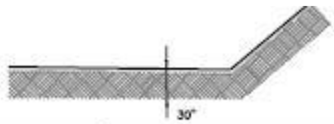


PLAN VIEW
NOT TO SCALE



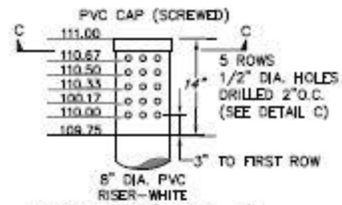
DETAIL B
NOT TO SCALE

BIORETENTION FACILITY
NOT TO SCALE



SOIL	SPECIFICATION	
40% SAND	SIEVE 8 16 50 100 200	% PASSING 100 70–100 15–35 2–15 0
20–30% TOPSOIL		
30–40% STABLE COMPOST		

BIORETENTION SOIL MIX



RISER PIPE (DETAIL A)
NOT TO SCALE

SECTION C–C
NOT TO SCALE

BIORETENTION PLANTING SCHEDULE

SYMBOL	COMMON NAME	SCIENTIFIC NAME	DELIVERED AS	NUMBER OF PLANTS
	RIVER BIRCH	BITULA NEGRA	2" CALIPER	3
	NORTHERN ARROWWOOD VIBURNUM	VIBURNUM RECOGNITUM	18" CONTAINER	7
	NINEBARK	PHYSOCRPUS OPULFOLUS	12" CONTAINER	9
	BIRDSFOOT–TREFOIL	LOTUS–CORNICALATAS	12" CONTAINER	15
	FINE–SHREDDED HARDWOOD MULCH		6 CUBIC YARDS	2–3" DEEP

Section 6.0 Design Summary and Conclusions: PRE VS. POST ANALYSIS

6.1 SUMMARY - DISCUSSION

The following informational charts are a synopsis of the comparative scenario models to determine the stormwater runoff conditions. The data is a result of mathematical models representing the pre and post developed conditions. The pre-developed results were compared to the post-developed results to determine the approximate sizing requirements of the BMP's to be used to mitigate the impacts due to development.

The following tables represent the site condition data and the results of the HydroCAD® Stormwater Modeling System by HydroCAD Software Solution, LLC to verify that the proposed stormwater management system will comply with the guidelines for *Soil and Water Conservation in Urbanized Areas of Massachusetts*, and the Commonwealth of Massachusetts adopted and referenced *Stormwater Management Handbook*.

The following summary tabulations are developed separately for each design storm event for the Point of Analysis described in Section 5.2.3. The design storm events include the 2-year, 10-year, 25-year, and 100-year design storm frequencies. The tabulations show the results of the entire stormwater management system to the points of analysis.

The complete stormwater models for the 2-year, 10-year, 25-year, and 100-year design storm frequencies are presented in Volume 2 of this report.

The Point of Analysis outlined in Section 5.2.3 above is reprinted here for reference:

Point of Analysis A: Wetland easterly at intermittent stream

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6.2 SUMMARY TABLES: PRE-DEVELOPED PEAK FLOW RATES VS. POST-DEVELOPED PEAK FLOW RATES

Storm Frequency	Rainfall (in)	Pre-Development (cfs)	Post-Development (cfs)	Difference (cfs)
2 Year Storm	3.00	**6.91**	**4.68**	**-2.23**
10 Year Storm	4.50	**14.42**	**13.89**	**-0.53**
25 Year Storm	5.30	**18.69**	**17.68**	**-1.01**
100 Year Storm	6.50	**25.25**	**23.25**	**-2.00**

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6.3 RIP RAP COMPUTATIONS AT PROPOSED OUTLETS

HEADWALL 10			
DOWNSTREAM CHANNEL (OR SPREADER) HYDRAULICS			
Channel Bottom Width =	N/A	ft	
Channel Total Depth =	N/A	ft	
Hydraulic Gradient =	N/A	ft/ft	
Left Side Slope =	N/A	(hor/vert)	
Right Side Slope =	N/A	(hor/vert)	
Depth of Flow =	N/A	ft	
Manning's "n" =	N/A		
Total X-sect Area =	N/A	s.f	
Effective X-sect Area =	N/A		
Wetted Permimeter =	N/A	ft	
Hydraulic Radius =	N/A	ft	
Top Width =	N/A	ft	
Velocity =	N/A	fps	
Peak Discharge Determined =	7.62	cfs	
La AND W CALCULATIONS:			
Culvert Diameter or Width of Channel (Do) =	1.50	ft	18" PIPE
*Tail Water Depth (TW) =	0	ft	
Length of Apron (La) =	**18**	ft	TW < Do/2
Length of Apron (La) =	N/A	ft	TW > Do/2
Width of Apron @ D.S. End (W) =	22	ft	TW < Do/2
Width of Apron @ D.S. End (W) =	N/A	ft	TW > Do/2
**Width of Apron @ D.S. End (W) =	N/A	ft	
**Width of Apron @ D.S. End (W) =	N/A	ft	
*If outlet to flat area, use TW depth = 0.2 x Do			
** (W) = bottom width of channel for well defined channel			
*** (W) = 3 times Pipe Diameter			
ROCK RIP RAP SIZE			
	Minimum		USE (in)
D50	0.67	ft	**8.00**
ROCK RIPRAP GRADATION (TABLE 7-24 OF NHDES HANDBOOK)			
% Passing	Stone Diameter (in)		
100	12.0	to	16.0
85	10.4	to	14.4
50	8.0	to	12.0
15	2.4	to	4.0
Minimum Rock Rip Rap Blanket Thickness =	**24.0**	in	
Minimum six inch sand and gravel bedding or geotextile fabric required under all rock riprap			

Use Length = 18', Gravel thickness = 24"

HEADWALL 40			
DOWNSTREAM CHANNEL (OR SPREADER) HYDRAULICS			
Channel Bottom Width =	N/A	ft	
Channel Total Depth =	N/A	ft	
Hydraulic Gradient =	N/A	ft/ft	
Left Side Slope =	N/A	(hor/vert)	
Right Side Slope =	N/A	(hor/vert)	
Depth of Flow =	N/A	ft	
Manning's "n" =	N/A		
Total X-sect Area =	N/A	s.f	
Effective X-sect Area =	N/A		
Wetted Permimeter =	N/A	ft	
Hydraulic Radius =	N/A	ft	
Top Width =	N/A	ft	
Velocity =	N/A	fps	
Peak Discharge Determined =	4.55	cfs	
La AND W CALCULATIONS:			
Culvert Diameter or Width of Channel (Do) =	1.0	ft	12" RCP)
*Tail Water Depth (TW) =	0.29	ft	
Length of Apron (La) =	**15**	ft	TW < Do/2
Length of Apron (La) =	N/A	ft	TW > Do/2
Width of Apron @ D.S. End (W) =	18	ft	TW < Do/2
Width of Apron @ D.S. End (W) =	N/A	ft	TW > Do/2
**Width of Apron @ D.S. End (W) =	N/A	ft	
**Width of Apron @ D.S. End (W) =	N/A	ft	
*If outlet to flat area, use TW depth = 0.2 x Do			
** (W) = bottom width of channel for well defined channel			
*** (W) = 3 times Pipe Diameter			
ROCK RIP RAP SIZE			
	Minimum		USE (in)
D50	0.52	ft	**7.00**
ROCK RIPRAP GRADATION (TABLE 7-24 OF NHDES HANDBOOK)			
% Passing	Stone Diameter (in)		
100	10.5	to	14.0
85	9.1	to	12.6
50	7.0	to	10.5
15	2.1	to	3.5
Minimum Rock Rip Rap Blanket Thickness =	**21.0**	in	
Minimum six inch sand and gravel bedding or geotextile fabric required under all rock riprap			

Use Length = 15’, Gravel thickness = 24”

6.4 CONCLUSION

On the issue of ensuring no increase in the post development peak flow rate of runoff, Standards 1 and 2 of the MassDEP Stormwater Handbook and associated regulations states:

> **Standard 1:** No new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth**.**
>
> All stormwater is treated prior to discharge.
>
> **Standard 2:** Stormwater management systems shall be designed so that the post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04.
>
> To prevent storm damage and downstream and off-site flooding, Standard 2 requires that the post-development peak discharge rate is equal to or less than the pre-development rate from the 2-year and the 10-year 24-hour storms. [9]

Then also,

> Proponents must also evaluate the impact of peak discharges from the 100-year 24-hour storm. If this evaluation shows that increased off-site flooding will result from peak discharges from the 100-year 24-hour storms, BMPs must also be provided to attenuate these discharges.

The location of the design point is a critical criteria, also defined in the Stormwater Handbook as:

> Measurement of peak discharge rates is calculated at a design point, typically the lowest point of discharge <u>at the downgradient property boundary</u>. The topography of the site may require evaluation at more than one design point, if flow leaves the property in more than one direction. (emphasis added).

Standard 1 and Standard 2 are met. The quantitative analysis of the peak flow rates tabulated above show no increase in the rate of runoff at the property lines at the Point of Analysis for the 2 year, 10 year, 25 year and 100 year storm events. The increase in post development runoff is properly attenuated by the proposed on – site stormwater controls and designs.

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[9] Massachusetts Stormwater Handbook, Volume 1: Standard 2, http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

Section 7.0 Documenting Compliance with STANDARD 3: RECHARGE

7.1 Recharge – Provide Required Annual Recharge (Rv)

7.1.1 Determine Required Recharge (Rv)

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

The following is a computation of the required Recharge Volume (Rv), the $Rv_{(LID)}$ after applying the LID Credit, and the provided Recharge Volume. All areas provided are somewhat approximate.

For the subject property, using the *Static Method* with the target factor of 0.25 based on Soil Group C, the computation follows:

Point of Analysis A: Wetland easterly at intermittent stream

Given:	HSG C =	0.25 in.
	$A_{IMP\ ROOF}$ (see 5.3.3 above)	40,400 ft^2
	$A_{IMP\ PAVEMENT}$ =	40,670 ft^2

Total Site Area: 9.84 Acres

RV **=** **(**40400 ft^2 + 40670) x 0.25 in) ÷ (12 in/ft) = 1689 ft^3 (prior to LID Credit)

Required Recharge (Rv) = 1689 ft^3

<u>Apply LID CREDIT 2:</u>

$RV_{(LID)}$ = (TOTAL ROOFS <u>LESS EXISTING HOUSE ROOF</u>)/TOTAL IMPERVIOUS AREA) X RV

$RV_{(LID)}$ = [(40400-3400) / (40400+40670)] x 1689 = **771 ft³**

Rv (Reduction) = (1689-771) / 1689 = 54% (ok – same as Section 5.3.3)

7.1.3 Determine Recharge Provided:

LID credits are allowed for providing recharge by disconnecting the roof runoff. However, due to the use of roof infiltration devices for 19 homes, the computation below will determine if enough recharge is provided by these units to meet the Required Recharge Volume (Rv) without using the LID Credit.

The Roof Runoff Infiltration design is shown on the plan set and is copied below in Figure 7.1 for reference. The concept is simple: gutters will be installed along the edges of the roofs of each dwelling and directed by downspouts and underground roof drain leaders to a two Cultec Recharger 330 units in series surrounded by stone. This system will allow for the direct and continuous infiltration of the clean runoff associated with the residential roofs. This infiltration will occur for most all storm events including the 40+ or so storm events that occur in this region each year. The purpose of the infiltration is to provide the annual recharge lost on the site due to paving and other impervious areas.

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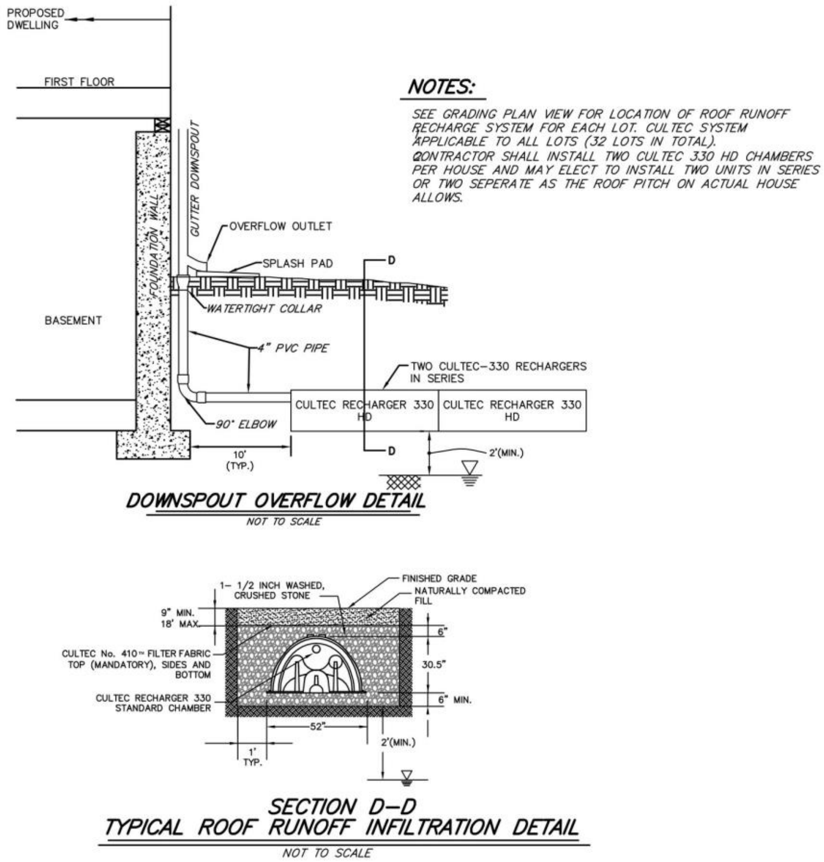
Figure 7.1 Typical Roof Runoff Infiltration Detail



Provided Recharge:

Given: 19 homes
2200 sf of roof area per house[10]
Cultec Recharger 330 with Stone provides 70.77 ft^3/unit
Cultec Recharger 330 with Stone area = 47.48 ft^2
Infiltration Rate: 0.27 in/hr (per Rawls Rate for C Soils – See Table 7.2)

A. Determine (pure) storage provided per lot without applying any infiltration:

$\boxed{\textbf{19 homes x 2 Cultec units / home x 70.77 ft}^3\textbf{/unit = 2689 ft > 1689 ft}^3\textbf{ > 771 ft}^3\textbf{ ok}}$

[10] Typical house footprint : Large Units 40x58, Smaller units 40x44 – Average Conservative = 2200

Therefore, the required recharge volume is 871 ft^3 when applying the LID Credit (53%) as outlined above. The provided storage (without accounting for any infiltration) of 2 cultec units in each of the 19 homes provides 2689 ft^3 of storage. This is 3 times the required recharge volume using the LID Credit.

Even without any credit for LID, the roof infiltration system will provide 1.7 times the required recharge volume. And further, this is accomplished without computing ANY infiltration rate (Dynamic method). So, in reality the recharge provided is actually greater than 3 times the required recharge volume.

Further, this analysis used only the roof infiltration systems and not the various rain gardens, or infiltration system in the cul-de-sac which will certainly infiltrate as designed.

In summary, the Required Recharge is clearly provided.

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7.1.3 Verify Basin (Roof Infiltration Systems) Drains

CHECK THAT ROOF INFILTRATION SYSTEMS DRAINS WITHIN 72 HOURS:

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

Where:

Rv = Storage Volume
K = Saturated Hydraulic Conductivity For "Static" and "Simple Dynamic" Methods, use Rawls Rate (see Table 8). For "Dynamic Field" Method, use 50% of the in-situ saturated hydraulic conductivity.
Bottom Area = Bottom Area of Recharge Structure

TABLE 7.2: 1982 RAWLS RATES[11]

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

Check Time to Drain (T_D) less than 72 hours with infiltration rate = 0.27 inches per hour (use full Recharge Volume without Credit)

T_D = Volume (ft³) / Infiltration Rate (ft/hour) x Area (ft^2)

T_D = 1689 ft³ / (0.27 in/hr) x (1 ft/12 in) x (47.48 ft^2 x 2 units x 19 houses)

T_D = 1689 ft³ / 40.5954 ft³/hour

[11] Rawls, Brakensiek and Saxton, 1982, Estimation of Soil Water Properties, Transactions American Society of Agricultural Engineers 25(5): 1316 - 1320, 1328

TD = 39.0 hours < 72 hours	Full Recharge Volume will Drain in less than 72 hours	**ok**

Moreover, check to verify Time to Drain if the soils are the worst HSG "C" type soil using the slowest infiltration rate of 0.17 inches per hour:

Check Time to Drain (T_D) less than 72 hours with infiltration rate = 0.17 inches per hour (use full Recharge Volume without Credit)

T_D = Volume (ft^3) / Infiltration Rate (ft/hour) x Area (ft^2)

T_D = 1689 ft^3 / (0.17 in/hr) x (1 ft/12 in) x (47.48 ft^2 x 2 units x 19 houses)

T_D = 1689 ft^3 / 25.5601 ft^3/hour

TD = 66.1 hours < 72 hours	Full Recharge Volume will Drain in less than 72 hours	**ok**

Therefore, in any condition, even in the worst soil, the roof infiltration systems will drain within 72 hours as required.

Standard 3 is accomplished for the full recharge requirement without the need for an LID Credit with nineteen (19) roof infiltration systems only. Other recharge systems proposed – rain gardens, bio-retention, infiltration trench - will only be a bonus to that which is required.

Section 8.0 Documenting Compliance with STANDARD 4: WATER QUALITY VOLUME

8.1 WATER QUALITY VOLUME – V_{WQ}

8.1.1 Water Quality Volume V_{WQ} – Brief Description of Requirement

Mass DEP outlines Standard 4 to address Total Suspended Solids as follows:

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

a. Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;

b. Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and

Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.

The formula for determining the Water Quality Volume is:

$$V_{WQ} = (DWQ/12 \text{ inches/foot}) * (A_{IMP})$$

Where:

V_{WQ} = *Required Water Quality Volume (in cubic feet)*

D_{WQ} = *Water Quality Depth: one-inch for discharges within a Zone II or Interim Wellhead Protection Area, to or near another critical area, runoff from a LUHPPL, or exfiltration to soils with infiltration rate greater than 2.4 inches/hour or greater; ½-inch for discharges near or to other areas.*

A_{IMP} = *Impervious Area (in square feet)*

For the subject project, it is not within a Zone II of a public water supply or any other required area for enhanced recharge nor as a hotspot so:

Use: D_{WQ} = 0.5 inch

8.1.2 Water Quality Volume VWQ at:

<u>Point of Analysis A</u>: Wetland at east portion of site at property boundary (from <u>SMF 1</u>) - 300 Series

Therefore:

$A_{IMP\ ROOF} =$ 40,400 ft^2
$A_{IMP\ PAVEMENT} =$ 40,670 ft^2

$V_{WQ} = (D_{WQ} / 12$ inches/foot) * (A_{IMP} square feet)
$V_{WQ} = (0.5$ *inch*/12 inches/foot) * (40,400 ft^2 + 40,670 ft^2)

$\mathbf{V_{WQ} = 3378\ ft^3}$

<u>Apply LID CREDIT 2:</u>

$V_{WQ} = (D_{WQ} / 12$ inches/foot) * (A_{IMP} pavement and roof)
$V_{WQ} = (0.5/$ 12 inches/foot) * (*40670+3378*[12])

$V_{WQ} = 1835\ ft^3$

Volume of Water Quality Provided in Rain Gardens & Chamber System (from HydroCAD) = [Rain Gardens 1-10] + Infiltration Chamber
(98+98+98+279+98+98+98+279+279) + 3166 = 1425 + 3166 = 4591 cubic feet.

Check Water Quality Volume without using LID Credit

V_{WQ} ^{Provided} **= 4591 ft^3**	**> V_{WQ}** ^{Required} **= 3378 cubic feet**	**------**		**OK**

Check Water Quality Volume using LID Credit

V_{WQ} ^{Provided} **= 4591 ft^3**	**> V_{WQ}** ^{Required} (with LID Credit) **= 1835 cubic feet**	**------**	**OK**

[12] *Roof of existing house is not part of LID as that roof currently and as proposed will not be directed to roof infiltration system therefore add back into impervious area.*

8.1.5 Total Suspended Solids (TSS)

The stormwater system is divided into two primary sections, which is purposefully the same as the phasing of the project.

Phase I to high point at Private Driveway Station 4+96

Phase II is remainder

Phase I:

The stormwater from Phase I will be directed into a vegetated swale along the edge of the roadway to a series of 8 rain gardens (4 on each side) and piped culvert crossings under the individual homeowner's driveways. The rain gardens are specially designed treatment devices that are also aesthetic and natural. "The rain gardens use soils, plants, and microbes to treat the stormwater before it is infiltrated or discharged."[13]

Near the intersection of the proposed private driveway and Long Ridge Road, two standard catch basins with 48" sumps will be provided for the very small drainage area relating to the first 100 feet or so of the private driveway. This is then collected in a piped system and discharged over a rip rap energy dissipation pad at a location <u>purposefully intended</u> to be over 100 feet from the wetland area.

Phase II:

Phase II includes the majority of the developed site. From the high point, the flow enters two standard catch bains with 48" sumps near Station 6+20 then discharges to a bio-retention area near Unit 18 on the south side of the private drive. This flow then is piped through a special catch basin(see below) eventually to the irrigation cistern, etc. per the description below.

The flow from the northern side of the private driveway is directed into the vegetated swale and into a series of two rain gardens similar to those described in Phase I. The area of the cul-de-sac is collected along the edge of the roadway by three special catch basins.

The special catch basins are proposed to be "Stormwater Buffer Zone" , a patented stormwater treatment system inside a 48" inside diameter concrete circular structure, similar in physical size to a standard catch basin. However, this system uses a combination of strainers, skirts, and and

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[13] MA Stormwater Handbook, Vol 2 Ch 2, page 23

membrane screens to separate and filter the runoff. The results have been studied extensively and are remarkable.[14] Also see Section 5.4.2 above.

The discharge from the three stormwater buffer zone structures at the cul-de-sac plus the flow from the bio-retention area and two rain gardens is then collected in a manhole and discharged to a 8000 gallon irrigation cistern which will be used for the storage facility for irrigating the developed property. This recharge is not included in the calculations above and is BONUS.

From the irrigation cistern, the flow is directed to a Cultec™ Chamber system manufactured by Cultec, Inc. of Brookfield, CT. comprised of 36 chambers immersed in a bed of stone. This is an “infiltration trench” as known by MassDEP lingo and is located over 100 feet from the wetland and will serve to infiltrate any runoff which is not used for irrigation into the ground as recharge. The exfiltration rate used is conservatively set at the lowest rate allowable, 0.17 inches per hour. This is in response to actual on location soil testing performed on December 3, 2014 which indicates “HSG C” soils. The lowest rate was used to be as conservative as possible. Flow that exceeds the capacity of the exfiltration will then discharge the system through a drain manhole and then piped to a discharge over a rip rap energy dissipation pad at a location approximately 55 feet from the wetland.

In summary, several LID and BMP techniques are being used to achieve the 80% TSS removal as outlined in the following MassDEP stormwater worksheets.

Standard 4 is met with the use of various LID and BMP techniques as described above and as outlined in MassDEP TSS Tables 8.1, 8.2, and 8.3 below.

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[14] http://www.stormwaterbufferzone.com/sbzverificationtesting.pdf

Table 8.1: Total Suspended Solids: Rain Gardens – Phase I and II

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

Version 1, Automated: Mar. 4, 2008

Location: The Birches

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Rain Garden	0.90	1.00	0.90	0.10
	0.00	0.10	0.00	0.10
	0.00	0.10	0.00	0.10
	0.00	0.10	0.00	0.10
	0.00	0.10	0.00	0.10

Total TSS Removal = 90%

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

Project: The Birches
Prepared By: JA Brem
Date: 12/5/2014

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

TSS = 90% which is greater than 80% required ------------ OK

Table 8.2: Total Suspended Solids: Bioretention – Phase II

INSTRUCTIONS:

Version 1, Automated: Mar. 4, 2008

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

Location: The Birches, Carlisle, MA

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Bioretention Area	**0.90**	**1.00**	**0.90**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**
	0.00	**0.10**	**0.00**	**0.10**

Total TSS Removal = **90%**

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

Project: **The Birches**
Prepared By: **JA BREM**
Date: **12/5/2014**

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

TSS = 90% which is greater than 80% required ------------ OK

Table 8.3: Total Suspended Solids: Proprietary "Stormwater Buffer Zone" and Infiltration Trench

Required to be completed manually due to use of Proprietary Device

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

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

Location: THE BIRCHES

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
STORMWATER BUFFER ZONE PROPRIETARY	0.626	1.00	0.626	0.374
INFILTRATION TRENCH	0.80	0.374	0.299	0.075

Total TSS Removal = 92.5%

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

Project: THE BIRCHES
Prepared By: JA BREM
Date: 12.5.14

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

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

Mass. Dept. of Environmental Protection

TSS = 92.5% which is greater than 80% required ------------ OK

8.1.6 REMAINING STORMWATER STANDARDS

The following is a brief discussion of Standards 5, 6, 7, and 8. See Section 9 for Standards 9 and 10.

Standards 5, 6 and 7 are not applicable to this project.

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

See Section 6.3 above for Rip Rap energy dissipation computations

See Erosion Control Plan – Sheet 8

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SECTION 9.0 OPERATION AND MAINTENANCE

9.1 INTRODUCTION

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

Standard 10: All illicit discharges to the stormwater management system are prohibited.[15]

Standard 9 and **Standard 10** are met with the following Operation and Maintenance Plan and Illicit Discharge Statement.

This section addresses the issue of operation and maintenance for the proposed Stormwater Management System – Standard 9 and an illicit discharge statement – Standard 10. If this section is separated from the remainder of this Stormwater Management Report (SMR), the SMR is hereby incorporated by reference, a copy of which will be in the records of the Carlisle Board of Appeals as well as other locations. The title of the final SMR is:

"THE BIRCHES"
A 40B RESIDETIAL DEVELOPMENT
OFF LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS
STORMWATER MANAGEMENT REPORT
July 1, 2014, latest revision 02-06-2015
Prepared For:
Lifetime Green Homes, LLC
142 Littleton Road, Westford, MA 01886
Prepared By:
Meisner Brem Corporation
142 Littleton Road, Ste. 16
Westford, MA 01886
MBC Job Number: 2066

The maintenance standards presented herein are based on Mass DEP "The Stormwater Handbook", as previously referenced, *the Federal and State Clean Water Acts, the Wetlands Protection Act, the Coastal Zone Act, a portion of the National Pollutant Discharge Elimination System Program and the Town of Carlisle Subdivision of Land Regulations* with various reports and guidance associated therewith.

[15] Massachusetts Stormwater Handbook, Volume 1: http://www.mass.gov/eea/agencies/massdep/water/regulations/massachusetts-stormwater-handbook.html

These maintenance and operations procedures are intended as general guidelines, however additional procedures shall be developed if necessary, as the systems are completed and operated over a period of time. As with all stormwater facilities, the conditions change or the management of them can be simplified as the operation personnel become more familiar with them. The most effective maintenance and operations can be customized to the specific facility as the system develops and situations merit.

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9.2 DESIGN PARAMETERS OF EROSION CONTROL AND MANAGEMENT

The US EPA has mandated that all land disturbance of greater than 1 acre at any one time seek a NPDES permit through the preparation of a Storm Water Pollution Protection Plan (SWPPP) to control the erosion potential and transfer of erodible soils off properties. The goal of a SWPPP is to provide suitable quantity and quality control measures for runoff, during and after construction, from a developed property, meeting the standards of the EPA and the Massachusetts Stormwater Management Policy. Ideally, the plan should be simplistic in design, cost effective to construct, and reasonable to maintain. The design should blend into the natural features and site resources and take full advantage of existing environmental mechanisms to accomplish mitigation.

Generally, storm water management systems are considered an element of the framework of an overall water resource system for a particular watershed. The designer first evaluates the impacts from a regional perspective, then narrows the focus to the specific site. As the designer determines the components of the specific site drainage system, various related factors, both regionally and locally are considered, evaluated, incorporated, and detailed into the engineering design.

Stormwater management combines a distinct range of interrelated variables to compose a unified program of action. These are divided into five categories:

- Design Issues: storm frequencies and intensities, soils, vegetation, groundwater, peak flows, quality treatment, life/safety
- Regional Issues: climate, watershed/ sub-basin relationship, environmental sensitivity to receiving waters
- Local Issues: adjacent land use, material specifications and availability, access and construction feasibility
- Costs: project costs, storm water management costs, cost/benefit analysis, land availability and value
- Maintenance: owner/manager of system, responsible entity, expertise, equipment handler, inspection, protection, monitoring

Using these parameters as a guide, the designer evaluates the site conditions, developing a drainage concept and performs hydrologic and design calculations to prepare the basis for the plan. The design concept is supported by the engineering hydraulic and routing calculations, the plan details and the material specifications of the drainage system components. A key component of a good design is an understanding of the requirements of maintenance, especially since many of these systems will be maintained by Homeowner's Association.

9.3 OPERATION AND MAINTENANCE OF STORMWATER MANAGEMENT FACILITIES

Proper maintenance is essential to ensure that the performance of the system meets the design expectation. A system that is not maintained may fail and could lead to financial loss, damage to surrounding infrastructure or environmentally sensitive areas and increasing the liability of the property owners.

9.3.1 Personnel and Education

Personnel make the difference between a Stormwater Management System that performs as designed throughout its lifetime or one that fails due to lack of attention. *Education* provides the personnel with the skills needed to effectively maintain a Stormwater Management System. *Record Keeping* allows the personnel to track the maintenance and the System's performance so as to determine when major maintenance tasks are required.

Maintenance of the structural components of the stormwater management facility will be the responsibility of the master Homeowner's Association (HO). Maintenance should be performed as outlined below in items 1-10. In addition to the town, each of the homeowners – through their association - should have a copy of this report with a copy of the grading design plan. Full comprehension of these documents will educate the homeowners and allow them to properly maintain the stormwater management system.

The HO should be aware of the Stormwater Management Facilities' intended purpose of removing contaminants from the stormwater runoff flow from the site. The result is the collection, removal and storage of the contaminants within the facility components. These potentially consist of trash/debris, oils, sediment and soluble/insoluble materials. In most situations, these can be handled, stored and disposed of with minimal safety requirements, in that the health hazards are non-existent or minimal with the concentrations involved. However, the HO shall be aware of the risk and/or the possibility of potential dangers. An example would be in the system was inundated with an excessive concentration due to an accidental spill.

9.3.2 Record Keeping

Record Keeping – It is recommended that a record log be kept of measured sediment levels at regular (annual) maintenance and after each major storm event. Sediment accumulation should be measured at each of the drop inlets and detention basin and logged in the record. Sediment should be removed annually, or when the sediment buildup has met the threshold outlined below. These activities should be logged as well.

Forms for recording the inspections and maintenance are included at the end of this section. The SWPPP will identify the party(ies) responsible for operations and maintenance, both temporarily and permanently.

9.3.3 Construction Erosion Control Process

Note: The "Operator" is the responsible party as defined by the US EPA in the NPDES regulations and is responsible for all site construction. The Operator may be the contractor or another party assigned during as part of the SWPPP.

9.3.3.1 Construction / Implementation

Stormwater management during construction should be considered as part of the construction operation of the whole site. A successful stormwater management system uses the various erosion control processes and components to work in tandem and in parallel to achieve the results of minimizing soil transport and protecting off-site areas from sediment conveyance. The Operator shall recognize and develop erosion control strategies to minimize soil erosion in the first instance, then to control its transport, and finally to capture any silt or sediment prior to discharge off site.
The Operator shall consider all of the following as part of the site excavation and erosion control strategy.

9.3.3.2 Minimize Disturbed Soil:

The contractor shall limit the disturbed areas to only those portions necessary for construction to proceed. The disturbance shall be limited to those times of year that will allow successful stabilization. Creation of work zones and phases are encouraged.

9.3.3.3 Source Controls: Stabilize Exposed Soil:

The contractor shall develop a construction plan for all areas that are exposed to soil erosion. These strategies could include maintaining tight soil compaction especially in proposed paved or impervious areas. Keeping all slightly sloped exposed gravel or subgrade areas compacted, especially prior to anticipated rain events, will serve to minimize the rilling and scouring of the soil and thus minimize soil transport. Other areas can be temporary loamed and seeded, especially areas intended to be grassed in the final plan. Common sense solutions to source control often yields the best erosion controls.

9.3.3.4 Prevent Runoff from Offsite Areas from Flowing Across Disturbed Areas

The contractor shall divert flow from offsite drainage areas away from disturbed areas by utilizing earth dikes, interceptor swales or other acceptable methods to ensure erosion of disturbed areas is minimized.

9.3.3.5 Slow Down Runoff Travelling Across the Site

The contractor shall utilize check dams, gradient terraces, sod, geotextiles or other acceptable methods where necessary in areas of steep slopes to ensure that erosion of unstable areas are minimized and to maximize soil infiltration.

9.3.3.6 Remove Sediment from Onsite Runoff Before it Leaves the Site

The contractor shall utilize temporary sediment basins for large (greater than ten acres) areas of disturbed soil to allow settling time for suspended solids. The location of temporary basins are shown on the construction plan set where necessary. All forms of erosion control are shown on the design plans and are to be located by survey to ensure appropriate placement of controls.

9.3.3.7 Meet or Exceed Local / State Requirements for Erosion Control.

The Contractor shall meet or exceed all additional Local and State requirements for erosion control and will ensure that all performance standards are met. Any changes required by the permitting authority shall be made within 7 days of the notification or an individual application should be submitted. The permittee shall update the plan as necessary to reflect any changes onsite, which may affect the potential for discharges of pollutants from the site.

9.3.3.8 Inspection and Maintenance Plan

1. Contractor shall use the blank inspection forms found within this Report or use alternative equivalent written inspection reports.
2. Inspections shall be logged on forms and reports and shall be completed by the Operator every 14 days and within 24 hours after a rainfall event over 0.25".
3. Proper record keeping for inspection and maintenance should be kept within the Storm Water Pollution Plan box installed on site. Blank inspection forms are included herein.
4. The inspector of pollution prevention measures should fully understand these Operation and Maintenance Requirements, the Storm-Water Pollution Prevention Plan, and NPDES permit with emphasis on erosion controls, spill prevention and cleanup, and inspection and maintenance.

5. The Operator shall instruct the Contractor to remove all sediment or debris whenever the volume is equal to 50% of the design capacity. This is imperative. All maintenance activity including silt removal, cutting of vegetation (mechanically or manually), and all other maintenance activities during the construction period shall be included in the Maintenance Logs / Reports.
6. The Operator is responsible to ensure the reliability of all measures of maintenance and erosion control measures including silt fence, mitigation swales, sedimentation pond, stabilized construction entrance and loam and seeding.
7. Maintenance of construction activities shall be performed in accordance with this Operation and Maintenance Plan and the Storm Water Pollution Prevention Plan. In general, maintenance should be performed on the specified intervals, or whenever the controls require maintenance for proper operation. If any conflicts exist, the Storm Water Pollution Prevention Plan shall be used.

9.3.4 Construction Operation and Maintenance schedule

The Operation and Maintenance (O&M) schedule during the construction phase is the responsibility of the **developer and/or site contractor**. The outline below shall be adhered to as closely as possible to ensure the proper construction and function of the drainage system.

1. Prior to construction, haybales and/or silt fence shall be installed per the approved plans. The erosion control barrier shall be inspected prior to a large storm event to ensure that it will function as required and following a storm to inspect for damage to the erosion control. Any damage or improper installation that is noticed prior to or following a storm event shall be promptly replaced or repaired in a satisfactory manner so as to prevent sediment from bypassing the silt fence barrier.

2. A stone construction entrance shall be installed at the entrance to the development and shall be 50’ long and 24’ wide. The entrance shall be cleared and once cleared, filter fabric shall be placed over the area which is to be overtopped by crushed stone to a depth of 6”. The stone size shall be 1 ½” with smaller stones only used to fill the leftover voids. Should the stone become clogged with sediment, it shall be replaced. The construction entrance shall be constructed with a temporary berm at the entrance to prevent flow of runoff onto the existing roadway.

3. The limit of clearing shown on the approved plan shall be adhered to as closely as possible. It shall be the contractor’s responsibility to determine the level of safety of standing trees.

4. In this construction operation and maintenance schedule, an area is considered stable if base course gravels have been installed in areas to be paved, a minimum of 85% vegetated growth

has been established, a minimum of three inches if non-erosive material such as stone or rip-rap has been installed, or erosion control blankets have been properly installed.

5. All areas shall be stabilized within 45 days of initial disturbance.

6. Temporary and permanent seeding specifications shall be obtained by the contractor by a qualified person/company and shall consult with the town's wetland expert prior to planting to ensure no adverse effects to the site.

7. In conjunction with construction, all drainage structures, including swales and detention basins, shall be constructed and stabilized as soon as possible and prior to directing runoff to them. Methods of stabilization include, but are not limited to, hydro seed, loam and seed, straw mulch, erosion control blanket, etc.

8. Silt sacks shall be installed in each catch basin and shall be inspected once per week and after every storm event of 0.5" or greater. Devices with sediment buildup shall have the sediment disposed of in accordance with all local, state, and federal regulations and have the silt sack cleaned or replaced.

9. All roadways shall be stabilized within 72 hours of achieving finished grade.

10. All areas of cuts and fills shall be seeded/loamed within 72 hours of achieving finished grade.

11. The smallest practical area shall be disturbed during construction, but in no case shall exceed 3 acres at any one time before disturbed areas are stabilized.

12. The swales, roadway culverts, and detention basins shall be inspected weekly or after a storm event of 0.5" or greater over a 24-hour period during construction. Any sediment buildup in the structures shall be promptly removed using a vacuum removal process and all debris removed in accordance with all local, state, and federal regulations.

13. The basins and swales shall be inspected weekly and after all rainfall events greater than 0.5" over a 24-hour period. Any erosion within the basin or swales shall be filled and re-stabilized in a manner to prevent future erosion. In addition, the outer portions of the basin shall be inspected in a similar manner.

14. **Standard Winter Notes:**

    a) All proposed vegetated areas that do not exhibit a minimum of 85% vegetative growth by November 15, or which are disturbed after October 15, shall be stabilized by seeding and installing erosion control blankets on slopes greater than 3:1, and seeding and placing 3 to 4 tons of mulch per acre, secured with anchored netting, elsewhere. The installation of erosion control blankets or mulch and netting shall not occur over accumulated snow or on frozen ground and shall be completed in advance of thaw or spring melt events.

b) All ditches or swales which do not exhibit a minimum of 85% vegetative growth by November15, or which are disturbed after November15, shall be stabilized temporarily with stone or erosion control blankets appropriate for the design flow conditions.

c) After November 15, incomplete road or parking surfaces, where work has stopped for the winter season, shall be protected with a minimum of three inches of crushed gravel per NHDOT item 304.3.

15. This schedule must be adhered to by the owner and/or contractor until the site is conveyed to a homeowner's association.

16. Lot disturbance, other than that shown on the approved plans, shall not commence until after the roadway has the base course to design elevation and the associated drainage in complete and stable.

9.3.5 Post-Development Operation and Maintenance schedule

Upon completion of construction, this Operation and Maintenance schedule shall be adhered to by the Homeowner's Association and their agents, advisors, consultants, and contractors, or any future agent with associated responsibility. The outline below shall be adhered to as closely as possible to ensure the proper function of the drainage system.

1. The private driveway shall be swept annually, at a minimum. Sweeping shall be done after the final snow melt when sand or de-icer can be easily swept. Any collected debris shall be removed in accordance with all local, state, and federal regulations.

2. The swales shall be cleaned four times per year and inspected monthly. In addition, the bottom and/or side slopes shall be mowed and all grass clippings and debris disposed of in accordance with all local, state, and federal regulations. No clippings shall be dumped within 100 feet of any wetland resource area.

3. The Bio-Retention Basin and rain gardens shall be inspected four times per year and any repairs made as necessary. The back side slopes of the Bio-Retention Basin and rain gardens shall be mowed at least once per year and the outlets inspected for signs of clogging and/or debris. Debris shall be disposed of in accordance with all local, state, and federal regulations. At least twice per year, inspection shall include erosion and/or cracking of the side slopes. If

this condition is noticed, repairs shall be made to immediately stabilize the affected area(s) and measures taken to prevent a reoccurrence.

4. The driveway culverts shall be inspected at least twice per year, including one time after the final snowmelt of the season, and any obstructions shall be removed and disposed of in accordance with all local, state, and federal regulations.

5. No erosion control measures shall be removed until all contributing upslope areas are stabilized.

9.3.6 Temporary Erosion Controls

The following erosion controls, as locations shown on the plans or otherwise installed, shall be used to limit soil erosion and transport during all construction phases:

1. Source Control: The best and most effective method of retaining soil and prohibiting transport is to use methods and techniques to prohibit the lifting, suspending, or transport of soil. These techniques include compaction, mixing, adding soil amendments including stabilizers, and surface treatment such as mulch, straw, jute matting, mesh, geotextiles fabrics, covers, and others
2. Silt Fence Barrier: A silt fence is a temporary barrier of geotextile fabric (filter cloth) attached to supporting posts and entrenched into the soil that is used to intercept sediment laden runoff from small areas of disturbed soil. The expected life of a silt fence is generally limited to 6 months.
3. Hay Bale Barrier: A Hay Bale barrier is a temporary barrier constructed of carefully stacked hay bales secured into the ground by embedding by digging a shallow 4" trough for the hay bale and securing them into the ground with wooden or steel stakes. Behind the hay bales, a silt fence is installed as described in 1 above. The expected life of a hay bale / silt fence is generally limited to 6 months.
4. Hay Bale/Silt Fence Barrier: Combination of 2 and 3 above. The hay bale is positioned on the high side.
5. Temporary Swale: Temporary swales are constructed channels with temporary vegetation for stabilization that intercept sediment-laden runoff and direct the flow to a secondary erosion control or into a natural drainage system. Swales can improve water quality by filtering and infiltrating the runoff. Installing stone check dams are quite easy to install and allows for sedimentation of the solids and easier cleaning.

6. Conveyance Swale: Conveyance swales are constructed open channels, some with dense vegetation, that are constructed to convey runoff and direct the flow to a BMP or to the discharge point into a natural drainage system. Conveyance swales direct the water to other BMP's and/or improve water quality by physically filtering and infiltrating the runoff and allowing for ionic exchange and chemical actions to aid in polishing the runoff.
7. Temporary Sediment Basins: Sediment basins are effective at ponding and detaining runoff enough to allow sedimentation. Temporary outlets allow for a discharge. In this project portions of the forebay and the detention basin will be utilized as temporary sediment basins. Sediment removal should be regular during construction. This should be done whenever the sediment is 12" deep or deeper.
8. Loam and Seed: Loam and seed establishes grasses on highly erodible soils or critically eroding areas. Loam and seed stabilizes the underlying soil, reduces damages from sediment, maintains or improves water quality and reduces stormwater runoff. On steeper slopes, jute matting, organic mesh, or other devices are used to retain the soil until a full lawn or slope is fully stabilized with mature grow in. Fertilizer and seed type and application rates are on the final drawings.

9.3.7 Permanent Best Management Practices

Operation and maintenance of the catch basins, inlets, drainage swales, rain gardens, Bio-Retention systems, infiltration systems, and associated drainage structures should occur as follows:

1. Catch Basins – Deep Sump and Stormwater Buffer Zone proprietary product – Inspect catch basins at least four times per year and at the end of the foliage and snow- removal seasons. Sediments must also be removed once per year, preferably in early May, or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. If handling runoff from land uses with higher potential pollutant loads or discharging runoff near or to a critical area, more frequent cleaning may be necessary.
2. Inlets – Pipe inlets and spillway structures should be inspected annually and after every major storm. Accumulated debris and sediment should be removed. If pipes are coated, the coating should be checked and repaired as necessary.
3. Outlets – Pipe outlets should be inspected annually and after every major storm. The condition of the pipes should then be noted and repairs made as necessary. If erosion is taking place, then measures should be taken to stabilize and protect the affected area of the outlet.
4. Earth Berm (embankment) –Vegetation – All vegetated areas should be inspected annually and after every major storm The vegetated areas within and around the stormwater

management facilities should be protected from damage by fire, grazing, traffic, and dense weed growth. Lime and fertilizer should be applied as necessary as determined by soil tests. Trees and shrubs should be kept off of the detention basin embankment and emergency spillway areas. Trimming, mowing, cutting of weeds and invasive vegetation is one of the primary components of maintenance and is usually quite easy if done regularly, at least once per year. Neglect though may create a much greater chore.

5. Bio Retention System and Rain Gardens – The Bio Retention System and Rain Gardens should be inspected four times per year and any repairs made as necessary. The basins shall be mowed at least once per year but may be mowed regularly. The outlets shall be inspected for signs of clogging and/or debris at least four times per year. Debris shall be disposed of in accordance with all local, state, and federal regulations. At least twice per year, inspection shall include erosion and/or cracking of the side slopes. If this condition is noticed, repairs shall be made to immediately stabilize the affected area(s) and measures taken to prevent a reoccurrence.

   Should sediment accumulations reach an average depth of greater than 4 inches, the sediment should be removed and properly disposed of. Earth berms should be inspected annually and after every major storm. The earth berm of the forebay and extended detention system should be inspected annually to determine if rodent burrows, wet areas, or erosion of the fill is taking place.

   All permanent impoundments should be inspected annually by a qualified professional engineer on a periodic basis to assure that no erosion has impacted the structural integrity of the embankments.

   The spillway shall be inspected annually and reconstructed if evidence of overtopping occurred with appropriate base course and rip rap constructed as necessary under the direction of a professional engineer.

   The plantings shall be healthy and restored to health or replaced, in kind or type, if found not so. The plantings shall be trimmed and pruned at least once yearly to assure that they do not outgrow their intended use or that of others.

6. Infiltration System – The Cultec Chamber Infiltration system should be inspected four times per year and any repairs made as necessary. The surface of the basin should be maintained as landscaped garden areas or lawn which shall be mowed at twice per year but may be mowed regularly. The overflow outlets inspected for signs of clogging and/or debris at least once per year. Any debris shall be disposed of in accordance with all local, state, and federal regulations. At least twice per year, inspection shall include checking the inspection port for water retention and other signs of partial or full failure. If this condition is noticed, an analysis with a written report and photographs should immediately be performed and any repairs shall be made as soon as possible.

Should sediment accumulations reach an average depth of greater than 12 inches, the sediment should be removed by flushing and vacuuming and properly disposed of.

7. Outlet Protection (riprap apron) – The outlet protection should be inspected at least annually and after every major storm. If the riprap has been displaced, undermined or damaged, it should be repaired immediately. The channel immediately below the outlet should be checked to see that erosion is not occurring. The downstream channel should be kept clear of obstructions such as fallen trees, debris, and sediment that could change flow patterns and/or tailwater depths on the pipes. Repairs must be carried out immediately to avoid additional damage to the outlet protection apron.
8. Vegetated swale – The vegetated swales should be inspected quarterly and during/after every major storm over 1" of rainfall. All cross culverts at driveway crossings should be kept clear and free of debris regularly. Should sediment buildup at the inlet or outlet of the driveway culverts (or other location) impede the free flow of stormwater through the culvert, the sediment should be immediately removed and properly disposed of.
9. Loam and Seed: Loam and seed establishes grasses on highly erodible soils or critically eroding areas. Loam and seed stabilizes the underlying soil, reduces damages from sediment, maintains or improves water quality and reduces stormwater runoff. On steeper slopes, jute matting, organic mesh, or other devices are used to retain the soil until a full lawn or slope is fully stabilized with mature grow in. Fertilizer and seed type and application rates are on the final drawings.
10. Construction Site Entrance – Stone pads are used to limit the transport of sediment from the times on construction and other vehicles. These pads should be maintained regularly. The construction site entrance should be removed once pavement is installed.
11. Stormwater Buffer Zone (via the MASTEP Stormwater Technologies Clearinghouse referenced in Section 5) - Stormwater Buffer Zone is cleaned by removing the street level inlet grate, removing and emptying the StormBrake gross pollutant trash strainer, and then removing material from the manhole sump using the same method and equipment that is used to clean standard catch basins. It is recommended that every maintenance procedure be recorded in the maintenance log for the site regardless of whether the unit is in construction period or post construction period use.

    Construction Period: Monthly visual inspection, and brushing off, or hosing off of treatment skirt from street level if needed, plus emptying the strainer of leaf litter, etc while removing it to see skirt. Removal of sediment from the manhole by vactor is not needed unless sediment level reaches treatment skirt, but recommended to be annually otherwise during construction period, or at the end of the construction period.

    Post Construction Period or Permanent Use: Annual inspection, Biannual cleanout(vactoring): Annual Maintenance; (but every four or six months during the first year): to include visual inspection of strainer and treatment skirt, emptying the strainer of leaf litter, trash, etc (all considered solid waste) while removing it to treat skirt, spraying off or brushing off underside of the treatment skirt, inspecting and recording sediment depth in manhole (if inspection is between cleanouts, or the depth prior to cleanout if unit is being vactored).

9.3.8 Other Site Controls

1. Good house keeping - The contractor is necessary for maintaining accurate and complete records of the construction activities on site. The contractor must also ensure that chemicals, pesticides, and fertilizers are properly stored. Regular disposal of garbage, rubbish or sanitary waste disposal, and prompt cleanup of spills is necessary to minimize the potential for pollution.

2. Waste disposal, sanitary septic disposal, and materials management - The proper management should include storage of hazardous materials such as paints, oils, etc. These materials should be stored in the contractor's vehicle or placed on an impervious floor or surface, i.e. (Basement floor or concrete slab.)

3. Spills - All personnel involved with the construction activities have knowledge of whom to contact in the event of a spill that is a source of storm water contamination. The contractor shall ensure that appropriate measures are taken to prevent spills and respond in the event of a spill. In the event of a spill the contractor should take measures to reduce storm water contact stopping the source of the spill, contain the spill, and absorb the material as quickly as possible.
4. Sanitary portable toilets shall be utilized to avoid direct discharge.
5. Vehicle wash down – in appropriate locations over 100 feet from wetlands draining to a sediment basin

9.3.9 Illicit Discharge Statement

As part of the final SWPPP for this project the Operator will certify, in writing, that no illicit discharges will be permitted on the property at all times during construction.

If any illicit discharge is accidentally released, the following protocol is to be utilized.

Releases of Reportable Quantities

If the construction site has a release of a hazardous substance or of oil in an amount which exceeds a reportable quantity as defined at 40 CFR Part 11, 40 CFR Part 117, or 40 CFR Part 302 then the permittee shall:

a) Call the National Response Center,

b) Modify the Pollution Prevention Plan as to the nature of the release and,

c) Submit a written description of the spill.

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9.3.5 Operation and Maintenance Generic Forms

See the following pages for the following forms:

- Best Management Practices – Summary of Inspections
- Grading and Stabilization Activities Log

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THE BIRCHES

STORMWATER MANAGEMENT REPORT – VOLUME 1 OF 2
A 40B RESIDENTIAL PROJECT OFF LONG RIDGE ROAD, CARLISLE, MA

Best Management Practices
Summary of Inspections

Project Site: ____________________

Location: ____________________

Phase or Limits: ____________________

Inspection Number	Date	Inspector	Item Inspected (see list @ right)	Condition/Remarks	Action to be Taken	Follow up Comments

List of Inspections

A. Hay Bale/Silt Fence
B. Sediment Ponds
C. Site Clearing, Grub
D. Storm Drain Pipe & Conveyance
E. BMP - Indicate type (mandatory)
F. Stone Condition
G. Velocity Dissipaters
H. Structural Components
I. Permanent Stabilization

Submittal Log

Date	Agency

Grading and Stabilization Activities Log

Date Grading Activity Initiated	**Description of Grading Activity**	**Description of Stabilization Measure and Location**	**Date Grading Activity Ceased** (Indicate Temporary or Permanent)	**Date When Stabilization Measures Initiated**

Use Additional Sheets if Necessary

EPA SWPPP Template, Version 1.0

9.3.6 Map of Best Management Practices (BMPs)