Effective Date: 2/4/12

EAST GRANBY

Low Impact Development and Stormwater Management Design Manual

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This project was made possible by a grant from the Connecticut Department of Environmental Protection through the Farmington River Enhancement Grant Program.

The grant is intended to support the formation of a local committee to:

- review existing municipal regulations and ordinances, and
- draft recommended changes to remove barriers to low impact development (LID) and create opportunity for low impact development practices to be employed in East Granby.

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Chapter 1
Introduction

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1.1 Importance of LID

The application of Low Impact Development (LID) strategies will create an ecologically friendly approach to land development. The LID approach is one that minimizes the adverse impacts of development and stormwater on the natural environment. This approach emphasizes the integration of site design and planning techniques that conserve natural systems and hydrologic functions on a site.

1.2 Purpose of the Manual

LID is a performance based approach to address changes in runoff volume, runoff rate and water quality, which adversely affect our environment. A primary objective of Low Impact Development is to mimic the pre-development hydrologic conditions on a site. This condition is known as "Hydrologic Transparency". At the current time, this objective is measured by two metrics.

The first is the reduction of the post-development runoff volume to the pre-development runoff volume for the 90% rainfall event. The second metric is to match the Runoff Curve Numbers (RCN) for post-development conditions to pre-development conditions. Along with the matching of the RCN, it is also important to have the post-development time of concentration (Tc) match or closely approximate the pre-development Tc. Water quality impacts are measured by performance based pollutant removal requirements.

1.3 How to apply the Manual

The design engineer must meet the required performance requirements in Tab 2 by utilizing one or more the stormwater practices specified in Tab 3. As the key aspect of the LID is meeting the performance requirements, there will be many appropriate solutions for a given project. The design engineer can be flexible in choosing the treatment systems which are most appropriate and cost effective for a project while meeting the performance requirements.

1.4 Guidelines for applying the Manual

Stormwater management for residential subdivisions shall be in compliance Section 3.11 of the East Granby Subdivision regulations. Site plans for commercial, industrial and high density residential projects shall comply with Section VI.D of the East Granby Zoning regulations.

The following LID performance requirements shall apply to the following land development projects: Residential Subdivisions, High Density Residential projects, Commercial/Industrial Site Plans, and Redevelopment of Commercial/Industrial sites*.

Required LID Performance Requirements

A. Groundwater Recharge Volume**,
B. Water Quality Volume,
C. Pollution Renovation Analysis.

Conditional LID Performance Requirements

A. Channel Protection Flow will be provided if the following condition exist:

   There is an increase in the peak rate of runoff from the proposed development that is to be discharged into an intermittent or perennial stream channel.

B. Flood Protection will be provided if the following conditions exist:

   I. For those sites no greater than 10 acres, and having no more than 20% total impervious coverage, the 10-year, 24-hour storm shall be used to design the facility.
   II. For a 10 acre site or less with more than20% impervious coverage, or a site greater than 10 acres, the 10-year, 24-hour and 100-year, 24-hour storm event shall be accommodated.

C. The Water Quality Flow will be provided for any off-line stormwater treatment system, such as surface sand filters, organic filters, infiltration basins, infiltration chambers and trenches. The Water Quality Flow shall be determined by the calculations stated in Section 2.1.F of this manual.

* Any commercial or industrial redevelopment site which proposes a modification of a minimum of 10,000 square feet of impervious cover shall provide the mandatory requirements.

** The Groundwater Recharge Volume shall only be provided for the impervious area associated with building roofs for those land uses with high pollutant loads as stated below.

Land Uses with High Pollutant Loads

A. Industrial Sites,
B. Outdoor storage and loading/unloading of hazardous substances,
C. Storage of road salt and associated loading areas (if unprotected from rainfall),
D. Gas stations,
E. Exterior vehicle maintenance and service facilities, & equipment storage areas.

Chapter 2
Stormwater Performance Requirements

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2.1 LID Performance Requirements

The Town of East Granby has determined that the following requirements as specified for various developments will be met to protect the high quality surface and groundwater which is present today. The purpose of these requirements is to lessen the hydrologic impacts associated with land development projects.

A. Groundwater Recharge Volume (GRv) (required)

Required for all Site Plan and Special Exception per Section VI.D of Zoning Regulations or for subdivisions per Section 3.11 of the Subdivision Regulations

To maintain pre-development hydrology, post-development stormwater must be infiltrated to maintain the appropriate pre-development infiltration rate. The required Groundwater Recharge Volume is defined as a function of the annual pre-development recharge rate for site-specific soil conditions, the 90% rainfall event (1" of rain/24 hrs), and the extent of impervious cover on a site. The objective of this requirement is to maintain groundwater levels to protect the average depth of the groundwater, stream and/or wetlands, and general soil moisture levels. The infiltration of stormwater does provide significant water quality benefits, such as reducing the amount of nutrients, metals, and pathogens in the stormwater.

By the maintaining the pre-development recharge rate, compliance with this requirement can reduce the volumetric requirements for other sizing criteria (channel protection and flood protection). Groundwater recharge must occur in such a manner that protects groundwater quality. All stormwater must pass through a pre-treatment facility under this requirement.

The volume required for Groundwater Recharge shall be based upon the amount of impervious area. The recharge requirements are based upon the pre-development natural hydrologic soil group (HSG). The groundwater recharge volume is defined as follows:

$$GRv = (P)(D)(I)/12$$

Where:

GRv = Groundwater Recharge volume (acre-feet)
P = 1" (90% rainfall event)
D = Recharge Factor, see Table 2.12
I = Impervious area (acres)

Table 2.1.1 - Recharge Factors Based on Hydrologic Soil Group (HSG)

HSG	Recharge Factor (D)
A	0.60
B	0.40
C	0.25
D	0.10

Description of Hydrologic Soil Groups (NRCS):

Group A: Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively well drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B: Soils having a moderate infiltration rate when thoroughly wet. These soils consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C: Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D: Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

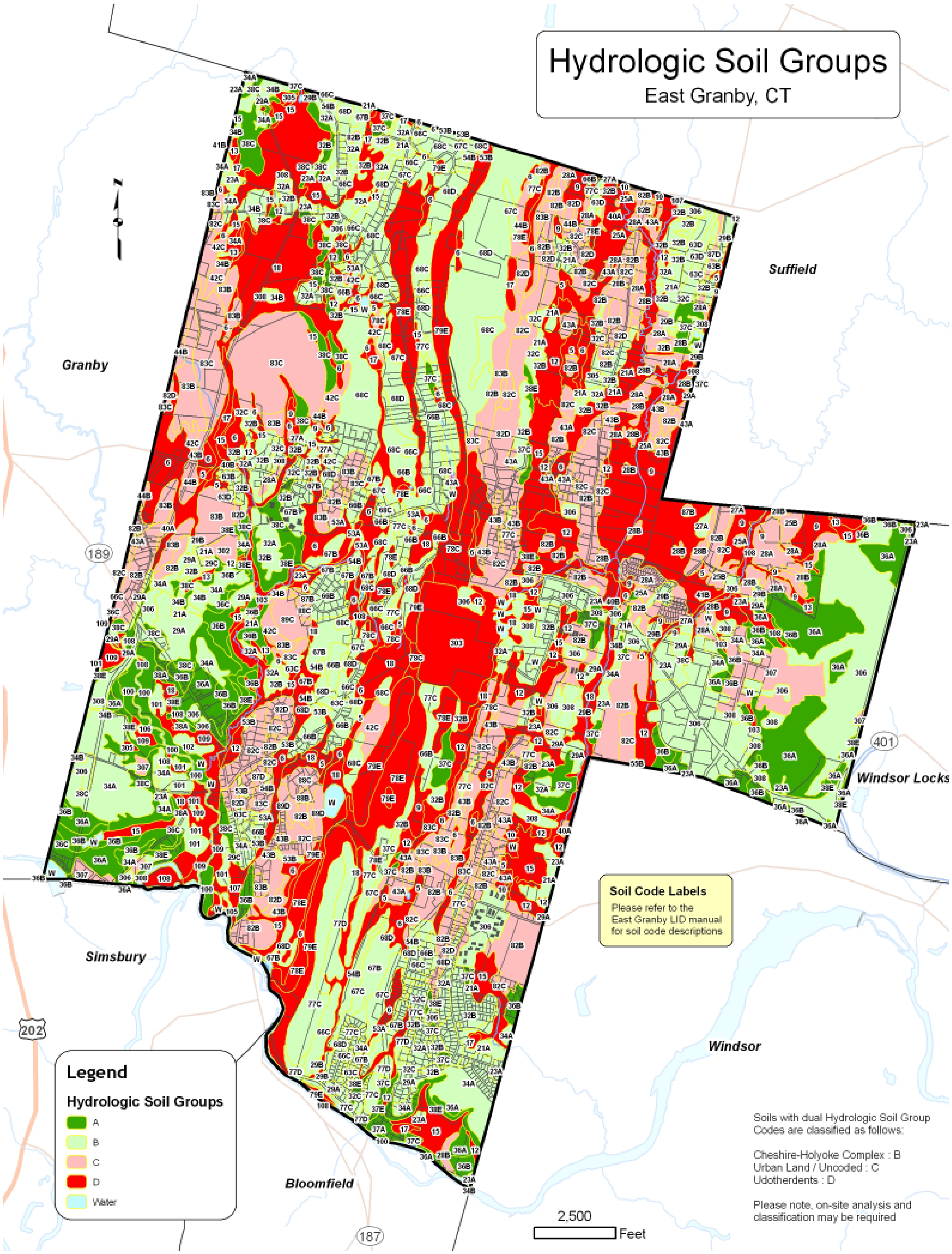

Figure 2.1.1 – Hydrologic Soil Groups

Soil Unit Name	Hydrologic Soil Group	Map Unit Number
Willbraham Series	D	5, 6
Scitico, Shaker & Maybid	D	9
Raynham	D	10
Raypol	D	12
Walpole	D	13
Scarboro	D	15
Timakwa & Natchaug	D	17
Catden & Freetown	D	18
Ninigret & Tisbury	B	21A
Sudbury	B	23A
Brancroft Series	C	25A, 25B
Belgrade	B	27A
Elmridge Series	C	28A, 28B
Agawam Series	B	29A, 29B, 29C
Haven & Enfield Series	B	32A, 32B, 32C
Merrimac Series	B	34A, 34B
Penwood	A	35B
Windsor Series	A	36A, 36B, 36C
Manchester Series	A	37A, 37C, 37E
Hinckley Series	A	38A, 38C, 38E
Ludlow Series	C	40A, 40B, 41B, 42C
Rainbow Series	C	43A, 43B, 44B
Wapping Series	B	53A, 53B, 54B
Watchaug	B	55B
Cheshire Series	D	63B, 63C, 63D
Narragansett Series	B	66B, 66C, 67B, 67C, 68C, 68D
Cheshire-Holyoke Series	B	77C, 77D
Holyoke-Rock Series	D	78C, 78E, 79E
Broadbrook Series	C	82B, 82C, 82D,83B, 83C
Wethersfield Series	C	87B, 87D, 88B, 88C, 89D
Suncook	A	100
Occum	B	101
Pootatuck	B	102
Rippowam	D	103
Hadley	B	105
Winooski	B	106
Limerick	D	107
Saco	D	108
Fluvaquents	D	109
Pits, Quarries	D	303
Udorthents-Pits	B	305
Udorthents-Urban Land	B	306
Udorthents, Smoothed	B	308

Table 2.1.2 – Town of East Granby Soil Names, Hydrologic Soil Group, & Map Unit Number (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm)

The hydrologic soil group must be verified by field data in the vicinity of the proposed groundwater recharge system. This data can be provided by a Certified Soil Scientist's field inspection of the site or soil tests performed by a professional engineer.

The groundwater recharge volume is part of the required water quality volume that must be provided for a project. Recharge must be provided in each separate, and distinct drainage area, where there is any impervious cover proposed. Runoff from a residential roof may be infiltrated without pre-treatment. Runoff from commercial or industrial roofs must be directed through a pre-treatment facility prior to infiltration.

B. Water Quality Volume (WQv) (required)

Required for all Site Plan and Special Exception per Section VI.D of Zoning Regulations or for subdivisions per Section 3.11 of the Subdivision Regulations

Stormwater runoff from a site must be adequately treated prior to discharge to a receiving wetland or watercourse. Different stormwater treatment systems may be utilized, both non-structural and structural. The objective of this standard is to minimize the adverse water quality impacts from non-point runoff on receiving water systems. Pollutant removal performance standards must be achieved at each discharge location based upon the water quality volume from 1" of runoff which is the runoff generated from a rainfall event of 1.2" per 24 hours. This is known as the water quality storm. All stormwater must pass through a pre-treatment facility under this requirement. Water Quality Volume is determined by the formula below. Pollutant removal efficiencies are defined in the following section.

The Water Quality volume is defined as follows:

WQv = (1")(I)/12

Where:

WQv = Water Quality Volume (acre-feet)
I = Impervious area (acres)

For those developed sites, such as a golf course which have little or no impervious areas, a minimum WQv of 0.2 watershed inches (0.2" over the entire disturbed area) is required. This minimum treatment volume is necessary to fully treat the runoff from the pervious surfaces. For the sizing of facilities to fully treat the WQv, the basis for the hydrologic and hydraulic evaluation shall be as follows:

Impervious coverage shall be measured from the site plan and shall include all impermeable surfaces (paved/gravel roads, driveway and parking lots, sidewalks, roof tops and patios set on a impermeable base)

The WQv must be provided in each separate, and distinct drainage area, where there is any impervious cover proposed. Any off-site area which is tributary to a proposed treatment facility must be accounted for the sizing of that specific practice. However, treatment is only required for the on-site areas. If there is a substantial off-site tributary area (>1 acre), the designer should design a by-pass system for the off-site drainage area.

C. Pollutant Renovation Analysis (required)

Required for all Site Plan and Special Exception per Section VI.D of Zoning Regulations or for subdivisions per Section 3.11 of the Subdivision Regulations

A pollutant renovation analysis is necessary to demonstrate that the proposed stormwater treatment system will achieve the required water quality goals. Achievement of these goals is a function of an accurate assessment of the pollutant loads expected to be seen by the treatment system and the design of the actual treatment system. The pollutant removal efficiencies to be achieved in the Town of East Granby are specified in Table 2.1.3 below.

In order to achieve the pollutant removal efficiencies stated in **Table 2.1.3**, the treatment system must be designed and constructed in accordance with all of the required design parameters as found in **Tab 3.** Table 2.1.4 provides concentrations of the pollutants of concern for common land uses. All concentrations are in mg/l.

Table 2.1.3 - Required Minimum Pollutant Removal Efficiencies

Pollutant Type	Minimum Pollutant Removal Rate
Total Suspended Solids	90%
Total Nitrogen	35%
Total Phosphorous	50%
Zinc	75%
Total Petroleum Hydrocarbons	80%
Dissolved Inorganic Nitrogen	35%

(Standards developed by Steven Trinkaus, PE)

Table 2.1.4 – Pollutant Concentration per Land Use Type

	Pollutant Concentration (mg/l)					
Land Use	TSS	TP	TN	Zn	TPH	DIN
Large Lot Residential (1 unit/5-10 ac)	60	0.38	2.1	0.161	0.50	0.51
Low Density Residential (1 unit/5 ac – 2 units/ac)	60	0.38	2.1	0.161	0.50	0.51
Medium Density Residential (2-8 units/ac.)	60	0.30	2.1	0.176	1.25	0.344
High Density Residential (8+ units/ac.)	60	0.30	2.1	0.218	1.5	0.344
Commercial	58	0.25	2.6	0.156	3.0	0.324
Industrial	80	0.23	2.1	0.671	3.0	0.569
Institutional (schools, churches, etc)	58	0.27	2.0	0.186	3.0	0.521

Land Use	Pollutant Concentration (mg/l) TSS	TP	TN	Zn	TPH	DIN
Open Urban Land	50	0.25	1.3	0.0	0.0	0.0
Transportation (roads only)	99	0.25	2.3	0.156	3.0	0.375
Decidous Forest	90	0.10	1.5	0.0	0.0	0.215
Evergreen Forest	90	0.10	1.5	0.0	0.0	0.215
Mixed Forest	90	0.10	1.5	0.0	0.0	0.215
Brush	90	0.38	1.5	0.0	0.0	0.215
Wetlands	0.0	0.38	1.5	0.0	0.0	0.10
Beaches	0.0	0.10	1.5	0.0	0.0	0.0
Bare Ground	1000	0.38	1.5	0.0	0.0	0.0
Row & Garden Crops	357	1.0	2.92	0.0	0.0	0.65
Cropland	357	1.0	2.92	0.0	0.0	0.215
Orchards/vineyards/horticulture	357	1.0	2.92	0.0	0.0	0.215
Pasture	145	0.38	2.2	0.0	0.0	0.65
Feeding Operations	145	0.38	2.2	0.0	0.0	0.8
Agricultural building, breeding & training facilities	145	0.38	2.2	0.0	0.0	0.8

Pollutant Removal Efficiencies for Treatment Systems:

Pollutant removal efficiencies are taken from the best available data for each type of treatment system. The sources of this information include the Center for Watershed Protection, the University of New Hampshire Stormwater Center, the EWRI/ASCE BMP Database, and the Massachusetts Stormwater Guidance Document.

Table 2.1.5 - Pollutant Removal Efficiencies (percent removal)

Type of System	Pollutant Removal Efficiencies (percent)					
	TSS	TN	TP	Zn	TPH	DIN
Extended Detention Shallow Wetlands	69	56	39	0	0	35
Subsurface Gravel Wetland	99	90	56	99	99	98
Pond/Wetland System	71	19	56	56	0	40
Wet Extended Detention Pond	80	35	55	69	0	36
Infiltration Basin	90	60	65	88	90	50
Infiltration Trenches/Chambers	80	55	60	99	99	50
Bioretention (Option 1 – see list below)	87	17	34	77	99	44
Bioretention (Option 2 – see list below)	87	60	34	77	99	60
Bioretention (Option 3 – see list below)	87	17	60	77	99	44
Bioretention (Option 4 – see list below)	87	60	60	77	99	60
Surface Sand Filter	87	32	59	77	98	33
Organic Filter	88	41	61	89	0	35
Dry Swale	50	0	8	50	81	0
Wet Swale	75	40	40	33	0	41
Vegetated Filter Strip	68	40	45	88	0	0
Permeable Pavement	99	0	60	75	99	0
Porous Concrete	97	0	40	99	99	0

Type of System	Pollutant Removal Efficiencies (percent)					
	TSS	TN	TP	Zn	TPH	DIN
Open Course Pavers	60	0	15	55	55	0
Deep Sump Catch Basins (48")	9	0	0	0	14	0
Dry Detention Pond	57	0	0	46	82	33
Oil / Grit Separator	0	0	0	17	0	47
LID Urban Planter	99	29	5	99	99	29
LID Curb Extension	99	29	5	99	99	29
Modular Wetland System	82	80	5	79	90	70
Filterra Bioretention System	85	40	60	62	80	40

(Values taken from professional literature review by Steven Trinkaus, PE)

Bioretention Option 1 (P-Index greater than 30)
Bioretention Option 2 (P-Index greater than 30 with IWS)
Bioretention Option 3 (P-Index less than 30)
Bioretention Option 4 (P-Index less than 30 with IWS)

Equations and Process

In 1987, Tom Schueler developed the Simple Method as a way to estimate pollutant loads for various chemical constituents on an annual basis. The Simple Method requires a small amount of information to be utilized; annual precipitation, pollutant concentrations, percent impervious cover and subwatershed areas. The formula of the Simple Method is as follows:

L = [(P)(Pj)(Rv)]/12(C)(A)(2.72) or reduced to L = 0.226(P)(Pj)(Rv)(C)(A), where

L = Pollutant load in pounds
P = Rainfall depth over desired time period (inches)
Pj = Factor that corrects P for storms that produce no runoff, use Pj = 0.9
Rv = Runoff coefficient, fraction of rainfall that turns to runoff,
Rv = 0.05 + 0.009(I)
I = Site Impervious coverage (percent)
C = Flow weighted mean concentration of pollutant (mg/l)
A = Area of site (acres)
0.226 = Unit Conversion Factor

The Simple Method provides reasonable estimates of changes in pollutant amounts resulting from different types of development. There are three aspects of the Simple Method that engineers need to keep in mind when using the equation.

It only estimates the pollutant load from storm events and does not consider pollutants from baseflow volumes. For large low density residential developments, where I < 5%, up to 75% of the annual runoff volume may be comprised of baseflow, the annual nutrient load associated with the baseflow may be equal to the annual load associated with the development.

Its primary usefulness is for calculating and comparing the relative storm water pollutant loads from various development concepts.

It provides an estimate of the pollutant loads that are likely close to the "true" but unknown value for a development project.

The Simple Method shall be used to calculate the pollutant load for the six pollutants required to be evaluated for stormwater discharges in the Town of East Granby. The following process shall be followed for the calculation of the pollutant loads and the effectiveness of the stormwater treatment systems.

<u>Pre-Development Conditions:</u>

I. Delineate the watershed areas on the site for undeveloped conditions for each design point or point of interest. A design point would typically be the point where a watercourse or overland flow would leave the site boundary. A point of interest could also be the limit of a delineated wetland or watercourse, located within the site's boundary.
II. Label and determine the area of each watershed on the site.
III. Determine the type of land cover for each watershed area. (For a retrofit or redevelopment site, the design engineer needs to make an assumption as to the type of land use cover which existed on the site prior to any type of development)
IV. Obtain annual rainfall amount in inches for the general location of the site.
V. Use the Simple Method to calculate the pollutants loads for the pre-development conditions.

<u>Post-Development Conditions:</u>

I. In order to fully integrate water quality into the site design, the type and location of the treatment systems need to be evaluated during the design phase and not at the end of the design period. The pollutant loading analysis should be prepared twice during the process; first during the Conceptual Design Phase in order to determine the type of treatment systems needed to achieve water quality goals. The second time is when the final site plan is complete and accurate values for impervious cover are available.
II. Prepare Conceptual Development Plan for project.
III. Delineate the watershed boundaries on the site for future conditions. Divide the watershed area into the area above the treatment system, which contributes to the treatment system, and the area below the treatment system.
IV. Calculate area of each watershed area.
V. Based upon proposed land use, estimate impervious coverage within each watershed area above the treatment systems.
VI. Calculate land area below the treatment system to the design point or point of concern. Only that area above the last treatment facility is run through the treatment system analysis. Pollutant loads from land below the last treatment system need to be calculated separately and can be added to the remaining load from the treatment system to determine the total load reaching the design point for future conditions. This is very important if TMDL limits are applicable to the receiving waterway.

VII. Use the Simple Method to calculate preliminary pollutant loads for post-development conditions on the site based upon the Conceptual Development Plan.
VIII. After the loads have been calculated for post-development, use the pollutant removal efficiencies provided and the formula below to determine the type(s) of treatment systems needed to achieve water quality goals.
IX. After the design engineer has determined what type of treatment system(s) are required, they can proceed with the final site design and incorporate the necessary storm water treatment system(s) as they prepare the final site design.
X. After the site design is complete, steps #3 through #8 are repeated with the accurate areas of the final watershed areas and impervious cover.

Pollutant Removal Calculation Procedure

I. (total load * 1st removal efficiency)
II. (total load – (load removed in #1))*2nd removal efficiency
III. (total load – (load removed in #1 + #2))*3rd removal efficiency
IV. (total load – (load removed in #1 + #2 + #3))*4th removal efficiency …

Total Percentage Removed by Treatment Systems

(load removed in #1+load removed in #2+load removed in #3….)/total load * 100

D. Channel Protection Flow (conditional)

If the calculated peak rate of runoff of the 2-year storm event for post-development conditions will result in a bank-full condition in the receiving watercourse, then the channel protection flow will be provided.

Natural stream channels must be protected from both changes in the peak rate and volume of post-development stormwater. The matching of the pre-development infiltration rate can address one of the major adverse impacts to stream channel morphology, however, the other major adverse impact, which is increases in the peak rate of runoff must be addressed.

The Channel Protection Flow addresses the increases in the peak rate of runoff and the adverse impacts on the hydromorphology of the stream channel.

One of two methods may be applied to achieve this goal as stated in the CT DEP 2004 Stormwater Quality Manual:

- Control the 2-year, 24-hour post-development peak flow rate to 50% of the 2-year, 24-hour pre-development level or,
- Control the 2-year, 24-hour post-development peak flow rate to the 1-year, 24-hour pre-development level.

The goal for this requirement is to maintain the depth and flow rate within a natural stream channel. This will minimize the adverse impacts to the stream channel itself as well as the benthic organisms which live in the bottom of the stream channel.

E. Flood Protection (conditional)

Once the volumetric and water quality requirements (GRv & WQv) have been met, the designer can then focus on the metric measuring the matching of the RCN values and then the potential changes to the peak rates of runoff. If there is still an increase in the peak rate of runoff for a development after meeting the groundwater recharge volume, then the increases in the peak rate of runoff for the 10-year, 24-hour and potentially the 100-year, 24-hour storm event must be reduced to the pre-development peak rate. These increases shall be reduced by the design and construction of appropriate structural measures.

I. For those sites no greater than 10 acres, and having no more than 20% total impervious coverage, the 10-year, 24-hour storm shall be used to design the facility.
II. For a 10 acre site with more than20% impervious coverage, or a site greater than 10 acres, the 10-year, 24-hour and 100-year, 24-hour storm event shall be accommodated.

Those impervious areas which are directed to infiltration systems, which will fully contain and infiltrate the required WQv can be removed from the calculation of the impervious area for that subwatershed area. In addition, other impervious areas where runoff occurs as overland flow and will flow across a minimum of 100’ of a pervious, vegetated surface (dense lawn, forest litter or meadow) can also be removed from the calculation. The total area of the subwatershed area shall remain unchanged, with only those connected impervious areas be included in the peak rate calculation for post-development conditions. The area of the excluded impervious area shall be considered as Forest in Fair Condition for the purposes of the hydrologic analysis.

For residential projects, where large extents of the site are preserved as undisturbed areas, this analysis will show how the RCN for post-development conditions can be reduced to become closer to or equal to the RCN for pre-development conditions. If the post-development calculation still shows an increase in the peak rate of runoff from the subwatershed area, then attenuation of the peak rate shall be required.

The primary objective of these sizing criteria is to prevent the increase in magnitude and frequency of storm events which exceed the bank full condition and spread out into the flood plain. A secondary objective is to prevent flood damage from the infrequent, but very large storms, protect the integrity of the stormwater management practice as well as maintain the existing boundaries of the pre-development flood plain.

F. Water Quality Flow (conditional)

The Water Quality Flow will be provided for any off-line stormwater treatment system, such as surface sand filters, organic filters, infiltration basins, infiltration chambers and trenches.

The Water Quality Flow is a peak rate associated with the water quality storm event. These systems must have a mechanism to by-pass those flows greater than the WQf. The WQf calculation uses the WQv and a modified curve number for small storm events. The following equation shall be used to determine the modified CN. The modified CN will then be used in a standard TR-55 model to estimate the peak rate for small storm events.

Using the WQv, a modified CN is calculated by the equation shown below:

$$CN = 1000/[10 + 5P + 10Q * \sqrt{(Q * Q + 1.25 * QP)}]$$

Where:

P = Rainfall in inches (use 1.2” for Water Quality Storm that produces 1” of runoff)
Q = Runoff Volume, in watershed inches (equal to total WQv / total drainage area)

Professional Engineers can use a TR-55 spreadsheet to find the WQf. Using the CN from the above equation, the time of concentration (Tc) and drainage area (A), the peak rate discharge (WQf) for the water quality event can be determined by the following procedure:

I. Read initial abstraction (Ia) from TR-55 Table 4.1 or calculate using Ia = 200/CN – 2
II. Compute Ia/P (P = 1.2 inches)
III. Approximate the unit peak discharge (qu) from TR-55 Exhibit 4-III using Tc and Ia/P
IV. Compute the peak discharge (WQf) using the following equation:

WQf = qu * A * Q

Where:

WQf = the peak discharge for water quality event in cubic feet per second (cfs)
qu = the unit peak discharge, in cfs/mi(squared)/inch
A = drainage area, in square miles
Q = runoff volume, in watershed inches (equal to WQv / A)

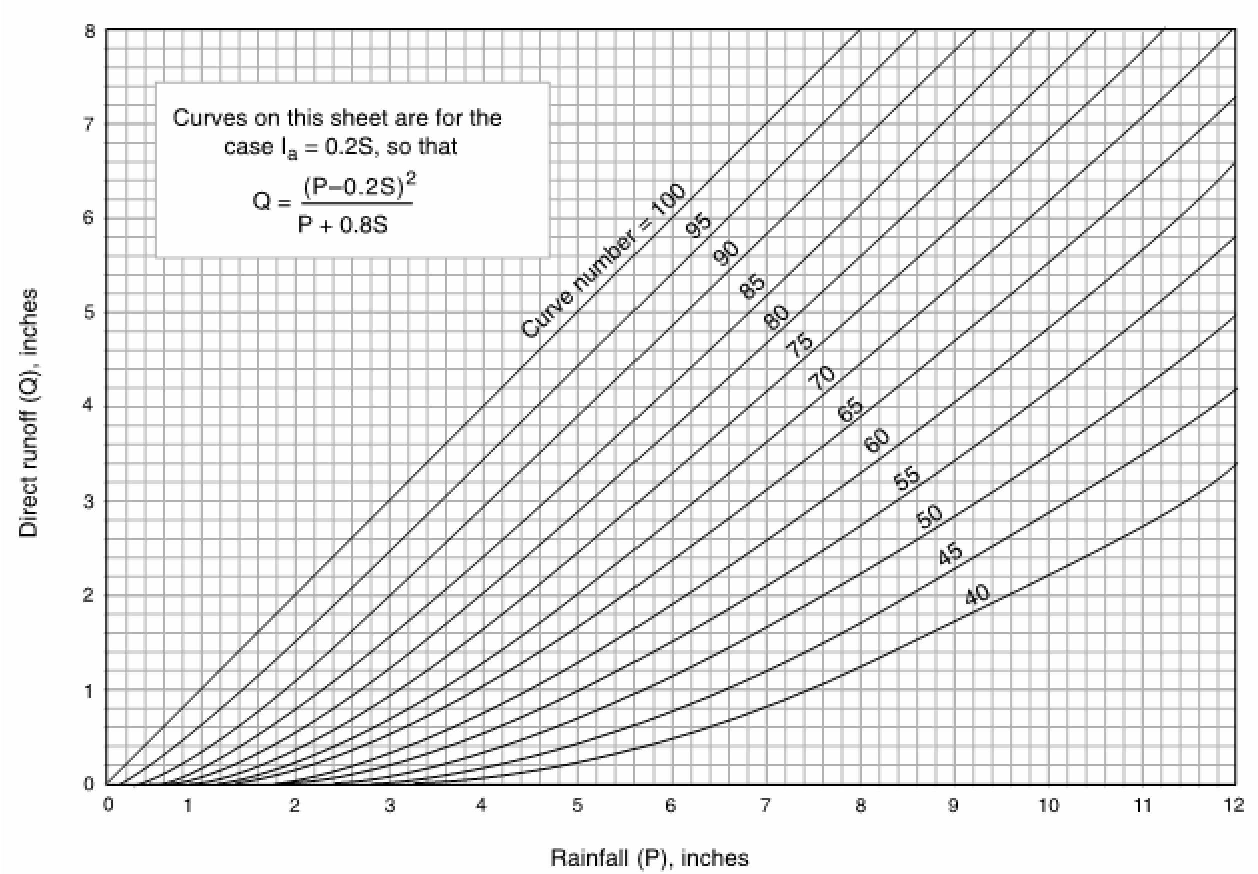

Figure 2.1.2 – "Figure 2-1: Solution of Runoff Equation (TR-55 manual)

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Figure 2.1.3 – “Table 4-1: Ia values for Runoff Curve Numbers” (TR-55 manual)

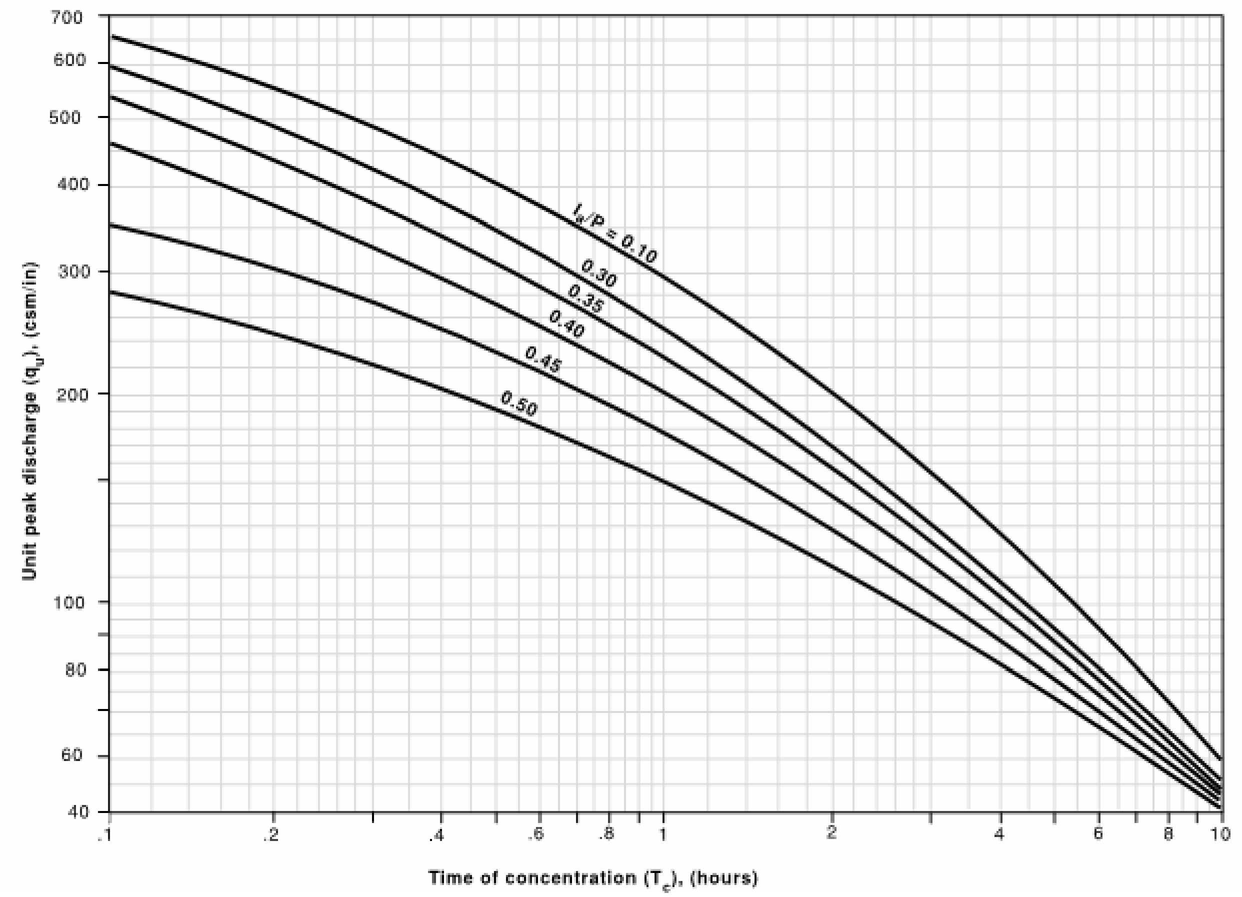

Figure 2.1.4 – "Exhibit 4-III: Unit peak discharge (qu) for NRCS (SCS) type III rainfall distribution (TR-55 manual)

2.2 Conventional Stormwater Performance Requirements Storm Drainage Planning

If conventional stormwater conveyance systems are necessary to collect and direct stormwater to one or more LID treatment systems which meet the performance requirements defined in Tab 2 of this manual, the following Town of East Granby standards shall apply.

A. **Storm Drainage Planning**:

All structural stormwater management systems in the Town of East Granby shall comply with these standards.

I. Be adequate for present and potential future uses based upon the maximum ultimate development of the watershed as permitted under existing zoning,
II. Not cause flooding of abutting property from the required headwater and backwater produced by bridges, culverts, and other structures,
III. Make provisions for the proper elimination of all stagnant water within the limits of the proposed project,
IV. To protect locations necessary for on-site sewage disposal and water supply facilities and driveways and building sites,
V. In compliance with all governmental codes and regulations and in accordance with the ordinances of the Town of East Granby and the standards set forth in these specifications, and
VI. In a manner capable of acceptance for public use and maintenance by the Town of East Granby although no such obligation shall be placed on the Town of East Granby as a result of this requirement.

B. **Design of in-road stormwater management systems:**

I. The design of storm drainage facilities shall be designed under the "Rational Formula" whereby Q=CIA, where:
   Q = Peak Rate of Runoff (cubic feet per second)
   C = Runoff Coefficient
   I = Rainfall Intensity
   A = Watershed Area
II. Runoff Coefficients as shown in Table 6.1:
III. Rainfall intensities used for storm drainage design shall be taken from the U.S. Weather Bureau “Rainfall Intensity – Duration Frequency Curves” for the Hartford rain gauge. Design rainfall frequency shall be:
   a. Pipe drainage systems; 25 year storm frequency,
   b. Channels and trunk lines; 25 year storm frequency,
   c. Culverts, where watershed is less than 1 square mile; 50 year rainfall frequency,

d. Culverts, where watershed is greater than 1 square mile; 100 year rainfall frequency.

IV. Drainage calculations for an in-road piped conveyance system shall provide the following information:

a. Plan showing watershed area for each structure,
b. Calculations showing the area, time of concentration, intensity, coefficients, flow, velocity, pipe size and slope of each pipe length.

C. **Construction Standards**:

Catch basins, manholes, drop inlets, end walls, and other appurtenances to the storm drainage system shall be constructed in accordance with Section 5.07 and Article M.08.02 of the latest revision of the Connecticut Department of Transportation's "Standard Specifications for Roads, Bridges, and Incidental Construction as amended."

D. **Drainage Facilities**:

I. Drainage facilities shall be located within the street right-of-way and enclosed in suitable conduit, where feasible. Where a development connects to existing Town of East Granby streets, the owner of the development project shall provide drainage at the intersections, as directed by the Planning and Zoning Commission (Commission).

II. Drainage facilities located outside the street right-of-way shall, unless modified by the Commission be located in perpetual, unobstructed drainage easements deeded to the Town of East Granby. Such easements shall be a minimum of twenty-five (25) feet wide centered on the drainage facility and, shall not overlap property lines.

III. Where it is necessary to discharge stormwater across private property not included in the development project, the owner of the development project shall obtain, in writing, permanent drainage rights in favor of the Town of East Granby for flows across adjacent properties. If the system is to be accepted by the Town of East Granby, the rights for the Town of East Granby to enter and maintain existing or proposed facilities shall be included. The owner of the development project shall submit copies of such agreement to the Commission prior to the final approval of the subdivision.

IV. Where approved by the Commission, open drainage shall be in swales or acceptable design with protection to prevent erosion and other damage to the slopes. Proposed surface drainage shall be designed and constructed in accordance with:

a. East Granby Low Impact Development and Stormwater Management Design Manual or
b. 2004 Connecticut Stormwater Quality Manual as may be amended or
c. 2002 Guidelines for Soil Erosion and Sediment Control as may be amended.

V. Where piped drainage will be provided, the first set of catch basins in a storm drainage system shall be located a maximum of 350 feet from the roadway high point or at the throat of an upgradient cul-de-sac. Spacing between sets of catch basins shall be a maximum of 300 feet. A drainage structure shall also be placed on each vertical grade change along a storm drain, at each change in horizontal direction, and at each junction point of two or more storm drains.

VI. All storm drain system outlets shall be terminated with an approved outlet structure and stabilized if needed. Easements for outlet pipes shall extend to a suitable existing storm drain or an adequate natural watercourse.

VII. No storm drain system shall outlet into a natural watercourse, whether continually flowing or intermittent, so as to exceed the capacity of the watercourse without provisions being made to satisfactorily increase the capacity of the watercourse.

VIII. Where required by the Commission for drainage purposes, the subdivider shall provide the Town with a channel or brook right-of-way at least the width of the channel or brook from the bank top to bank top plus a ten (10) foot access strip with a minimum width of twenty-five (25) feet.

E. **Standards for Drainage Pipes**:

All drainage pipes shall conform to the following specifications:

I. All pipe material shall be reinforced concrete pipe except where waived by the Commission.

II. The pipe system should flow full for the calculated total flow.

III. The system should operate under pressure with a free outfall.

IV. The HGL (Hydraulic Grade Line) should not rise to within two (2) feet of any manhole cover or top of any inlet at the design discharge.

V. The HGL should not rise to a level that would flood any subdrain outfalling into the storm drain system.

VI. Minimum slope of all pipes shall be 0.4%. The minimum pipe inside diameter shall be fifteen (15) inches.

VII. Energy dissipaters, stilling basins, or other approved devices must be incorporated when design slopes exceed 4.0%.

VIII. The minimum cover over the top of the pipe shall be three (3) feet.

F. **Underdrains:**

At the base of uphill shoulder embankments and as elsewhere required by the Town Engineer, a minimum 6 inch diameter perforated pipe continuous underdrain shall be installed behind the curbing in accordance with Section 7.51 of the latest Connecticut Department of Transportation specifications, except that the aggregate shall be limited to Broken Stone or Screened Gravel conforming to Article M.01.01 for 3/8 inch stone.

G. **Drainage Construction:**

I. Pipe Materials: Reinforced Concrete Pipe (RCP), joint sealants and bedding material shall conform to Article M.08.01 of the latest revision of the Connecticut Department of Transportation's "Standard Specifications for Roads, Bridges, and Incidental Construction."

II. Methods: Excavation and backfill shall conform to Section 2.05 of the latest Connecticut Department of Transportation specifications. Reinforced Concrete Pipe (RCP), joint sealants and bedding installation shall conform to Section 6.51 of the latest revision of the Connecticut Department of Transportation's "Standard Specification's for Roads, Bridges, and Incidental Construction."

III. Appurtenances: Catch basins, manholes, drop inlets, end walls, and other appurtenances to the storm drainage system shall be construction in accordance with Section 5.07 and Article M.08.02 of the latest revision of the Connecticut Department of Transportation's "Standard Specification's for Roads, Bridges, and Incidental Construction."

IV. Special Structures: Bridges, box culverts, and other special structures shall be designed and constructed in accordance with sound engineering practice and the latest revision of the Connecticut Department of Transportation's "Standard Specification's for Roads, Bridges, and Incidental Construction." Bridges shall be designed in accordance with the latest revision of the Standard Specifications for Highway Bridges as adopted by the American Association of State Highway and Transportation Officials (AASHTO).

H. **Private Drains:**

I. The size and location of all private storm drains that connect to the Town of East Granby storm drainage system shall be approved by the Commission prior to installation. Yard, cellar, or foundation drains that connect to the storm drainage system shall be shown on the final "as-built" survey of the drainage system.

II. For any private storm drain, the owner of the development project shall file a waiver with the Commission relieving the Town of East Granby of any responsibility in the event of any failure of the private storm drainage system. This waiver shall be transferred with the deed of the property to the prospective buyers.

Table 2.2.1 – Rational Method Runoff Coefficients

Land Use	Runoff Coefficient
Business, Downtown	0.70 – 0.95
Business, Neighborhood	0.50 – 0.70
Residential:	
Single Family	0.30 – 0.50
Multi – detached	0.40 – 0.60
Multi – attached	0.60 – 0.75
Suburban	0.25 – 0.40
Industrial	
Light use	0.50 – 0.80

Heavy use	0.60 – 0.90
Parks	0.10 – 0.25
Playgrounds	0.20 – 0.35
Streets/sidewalks	0.95
Driveways, gravel	0.75 – 0.85
Roofs	0.95
Lawns:	
Sandy soils, 2% slope`	0.10
Sandy soils, 7% slope	0.20
Sandy soils, >7% slope	0.22
Heavy soils, 2% slope	0.35
Heavy soils, 7% slope	0.40
Heavy soils, >7% slope	0.60
Agricultural Land:	
Bare packed soil	0.20 – 0.60
Cultivated rows	0.15 – 0.45
Crop land	0.10 – 0.20
Pasture, heavy soil	0.15 – 0.45
Pasture, sandy soil	0.05 – 0.25
Woodlands	0.05 – 0.25

Chapter 3
LID Design Requirements and Construction Specifications

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There are six categories for required design elements and guidelines for each type of stormwater treatment system. The categories are feasibility, conveyance, pretreatment, sizing criteria, treatment, and maintenance. The following pages provide detailed design parameters for each type of LID treatment system to be used to address stormwater issues in the Town of East Granby.

All designers must adhere to all of the applicable stormwater and performance standards found in this manual. The typical details provided for the various types of treatment and storage systems are schematic in nature and may be adjusted by the designer to fit particular site conditions. Final design plans for any type of treatment or storage system shall include all relevant design specifications for that particular system.

Table 3.1.1 and 3.1.2 have been developed to assist the design engineer in determining the optimum configuration of treatment systems to meet stormwater and water quality performance requirements as specified in Tab 2.0 of this manual.

Table 3.1.1 – Stormwater System Matrix

Stormwater Treatment Device Selection Matrix

Stormwater Treatment Systems	GRv	WQv	PT	FP
FILTERING SYSTEMS				
Bioretention (page 33)	■	■		
Tree Filter (page 37)	■	■		
Surface Sand Filter (page 39)	■	■		
Organic Filter (page 41)	■	■		
Dry Swales (page 43)	■	■		
INFILTRATION SYSTEMS				
Infiltration Trenches (page 45)	■	■		
Infiltration Chambers (page 47)	■	■		
Infiltration Basins (page 49)	■	■		
Alternative Paving Surface (page 51)	■	■		
WET VEGETATED TREATMENT SYSTEMS				
Extended Detention Shallow Wetlands (page 54)		■		■
Subsurface Gravel Wetlands (page 56)		■		
Pond / Wetland System (page 58)		■		■
Wet Swales (page 60)		■		
PRETREATMENT FOR WATER QUALITY SYSTEMS				
Filter Strip (page 62)			■	
Sediment Forebays (page 64)			■	
Deep Sump Catch Basins (page 66)			■	
Proprietary Treatment Devices (page 68)			■	
WATER QUANTITY CONTROL				
Wet Extended Detention Pond (page 70)				■
Dry Detention Pond (page 72)				■
WATER QUALITY CONTROL FOR COMMERCIAL RETROFITS				
LID Urban Planter (page 74)	■	■		
LID Curb Extension (page 76)	■	■		
Modular Wetland System (page 79)		■		
Filterra Bioretention System (page 81)		■		

GRv: Groundwater Recharge Volume
WQv: Water Quality Volume
PT: Pretreatment
FP: Flood Protection

Table 3.1.2 – Treatment System Matrix

POLLUTANT REMOVAL RATING	**Excellent**	**Very Good**	**Good**	**Fair**	**Poor**
Pollutant Removal Efficiency	**80 – 95%**	**70 – 80%**	**55 – 70%**	**40 – 55%**	**< 40%**
Color Coded System	(dark green)	(yellow-green)	(bright green)	(orange)	(yellow)

Stormwater Treatment System Pollutant Removal Selection Matrix

Stormwater Treatment Systems	TSS	TN	TP	Zn	TPH	DIN
FILTERING SYSTEMS						
Bioretention (page 33) – Option 1	Excellent	Poor	Poor	Very Good	Excellent	Fair
Bioretention (page 33) – Option 2	Excellent	Good	Poor	Very Good	Excellent	Good
Bioretention (page 33) – Option 3	Excellent	Poor	Good	Very Good	Excellent	Fair
Bioretention (page 33) – Option 4	Excellent	Good	Good	Very Good	Excellent	Good
Tree Filter (page 37)	Excellent	Poor	Poor	Very Good	Excellent	Poor
Surface Sand Filter (page 39)**	Excellent	Poor	Good	Very Good	Excellent	Poor
Organic Filter (page 41)**	Excellent	Poor	Good	Excellent	Poor	Poor
Dry Swales (page 43)	Fair	Poor	Poor	Fair	Very Good	Poor
INFILTRATION SYSTEMS						
Infiltration Trenches (page 45)	Excellent	Good	Good	Excellent	Excellent	Fair
Infiltration Chambers (page 47)	Excellent	Good	Good	Excellent	Excellent	Fair
Infiltration Basins (page 49)**	Excellent	Good	Good	Excellent	Excellent	Fair
Permeable Pavement (page 51)	Excellent	Poor	Good	Very Good	Excellent	Poor
Porous Concrete (page 51)	Excellent	Poor	Poor	Excellent	Excellent	Poor
Open Course Pavers (page 51)	Good	Poor	Poor	Good	Good	Poor
WET VEGETATED TREATMENT SYSTEMS						
Extended Detention Shallow Wetlands (page 54)**	Very Good	Good	Poor	Poor	Poor	Poor
Subsurface Gravel Wetlands (page 56)**	Excellent	Excellent	Good	Excellent	Excellent	Excellent
Pond / Wetland System (page 58)**	Very Good	Poor	Good	Good	Poor	Poor
Wet Swales (page 60)	Very Good	Poor	Poor	Poor	Poor	Fair
PRETREATMENT FOR WATER QUALITY SYSTEMS						
Filter Strip (page 62)	Good	Poor	Fair	Excellent	Poor	Poor
Stand Alone Sediment Forebays (page 64)	Very Good	Poor	Poor	Good	Good	Poor
Deep Sump Catch Basins (page 66)	Poor	Poor	Poor	Poor	Poor	Poor
Oil/Grit Separator (page 68)	Poor	Poor	Poor	Poor	Poor	Poor
WATER QUANTITY CONTROL						
Wet Extended Detention Pond (page 70)**	Excellent	Poor	Fair	Good	Poor	Poor
Dry Detention Pond (page 72)**	Fair	Poor	Fair	Fair	Excellent	Poor
WATER QUALITY CONTROL FOR COMMERCIAL RETROFITS						
LID Urban Planter (page 74)	Excellent	Poor	Poor	Excellent	Excellent	Poor
LID Curb Extension (page 76)	Excellent	Poor	Poor	Excellent	Excellent	Poor

Stormwater Treatment Systems	TSS	TN	TP	Zn	TPH	DIN
Modular Wetland System (page 79)						
Filterra Bioretention System (page 81)						

(Table developed by Steven Trinkaus, PE)

** Includes Forebay as part of treatment system

TSS: Total Suspended Solids
TN: Total Nitrogen
TP: Total Phosphorous
Zn: Total Zinc
TPH: Total Petroleum Hydrocarbons
DIN: Dissolved Inorganic Nitrogen

3.1 – BIORETENTION (GRv & WQv)

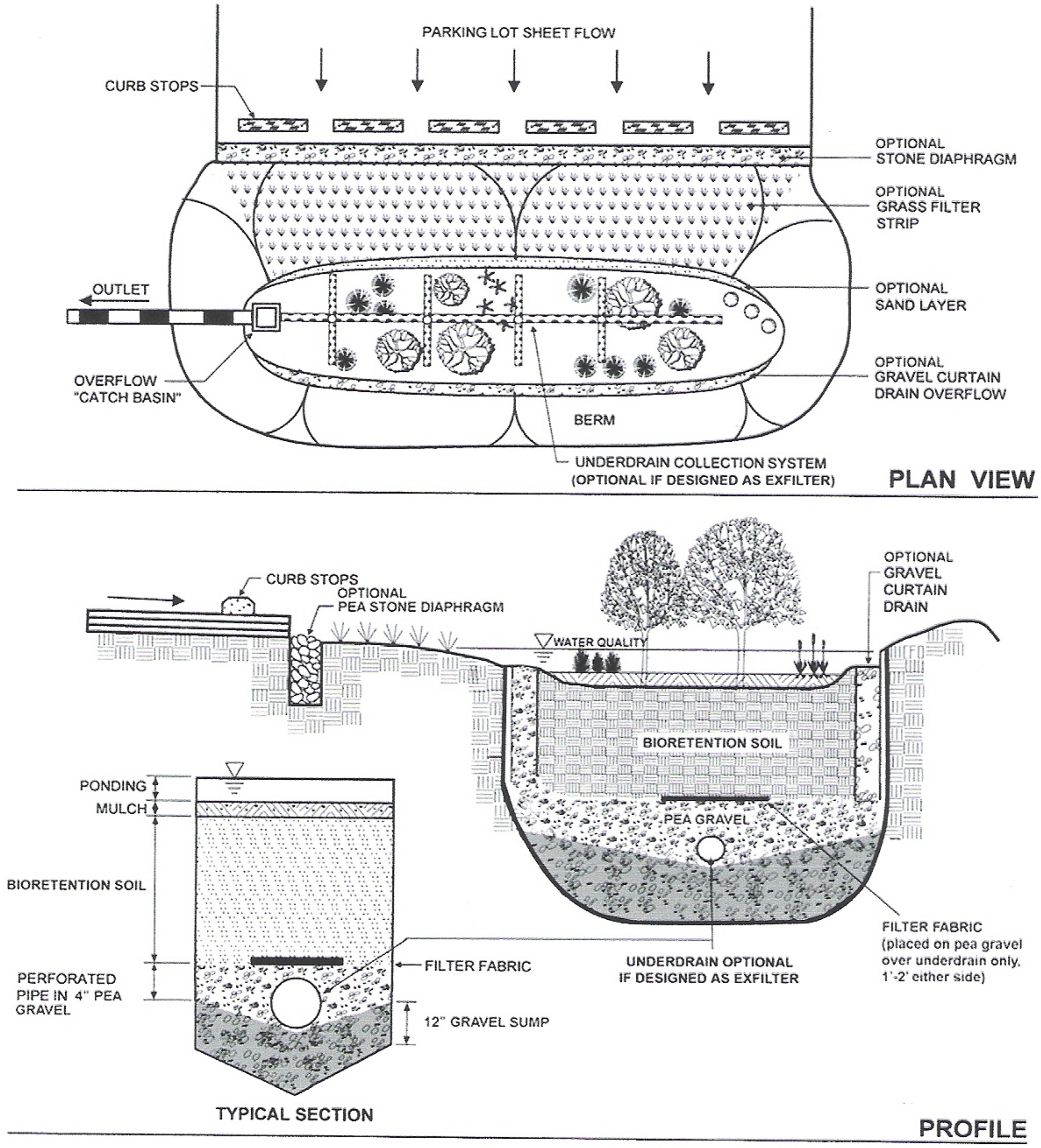


Figure 3.1.a – Typical Bioretention (RI DEM, 2010)

Table 3.1.a – Bioretention Design Parameters

Design Parameter	Residential Roof or Driveway Runoff	Runoff from Commercial Roof	Runoff from Commercial Driveway or Parking Area
Deep Test Pit	Yes, min. 6' in depth	Yes, min. 8' in depth	Yes, min. 8' in depth
Percolation Test	Yes, 24-30" deep	Yes, 30-36" deep	Yes, 30-36" deep
Depth of Soil Media	18"	24"	30"
Separation to SHGW from bottom of soil media	12" for A Soils 6" for B & C Soils*****	24" for A Soils 6" for B & C Soils*****	24" for A Soils 12" for B & C Soils*****
Underdrain (raised)	Not required for A & B soils Required for C Soils	Not required for A soils Required for B & C Soils	Not required for A soils Required for B & C Soils
Depth of Pea Gravel Layer above underdrain	3"	3"	3"
Depth of 1-1/4" crushed stone for underdrain layer	12"	12"	12"
Enhanced Nitrogen Removal (Internal Water Storage)**	Saturate bottom 6" of Soil Media Layer	Saturate bottom 12" of Soil Media Layer	Saturate bottom 12" of Soil Media Layer
Overflow Provisions – Top of pipe set at max. ponding depth	No, for A Soils Yes, for B & C Soils	No, for A Soils Yes, for B & C Soils	No, for A Soils Yes, for B & C Soils

* Separation to SHGW may be reduced by 50% provided that the surface ponding depth is reduced by 50% and the surface area of the Bioretention facility is increased accordingly to contain required WQv.
** See Detail below for Internal Water Storage Design
(Table 4.1.a is based upon research and literature review by Steven Trinkaus, PE

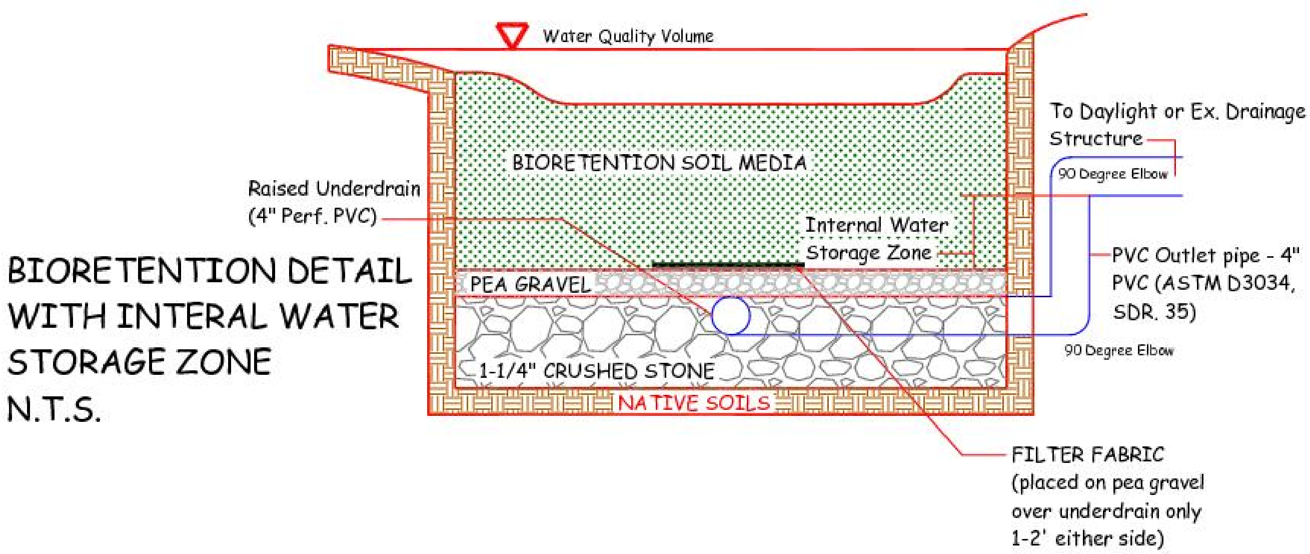


Figure 3.1.b – IWS Concept by Dr. William Hunt, NCSU)

Required Design Elements for Bioretention

FEASIBILITY:

- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level for systems serving roads, parking lots & commercial roofs.
- Vertical separation from bottom of soil media to SHGW shall conform to the requirements found in Table 7.1.a
- The maximum drainage area to a Bioretention system shall be five (5) acres.
- Deep test pit and percolation test must be performed within 15' of proposed Bioretention system.

CONVEYANCE:

- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- Conveyance to the facility shall overland flow from the adjacent land area or via a 4-6" drain pipe (roof drain outlet) onto a pad of field stones to dissipate flow velocities.

PRETREATMENT:

- Pretreatment shall be required for runoff from connected impervious areas as flow across a vegetated filter strip or grass swale to the facility. A gravel diaphragm can be used for the discharge of sheet flow from the edge of a parking facility.
- No pretreatment is required for runoff from residential or small commercial building roofs (4,000 sq.ft. or less).

SIZING CRITERIA:

- The maximum permissible ponding depth shall be 12"(1.0') for a Class A soil, 9"(0.75') for a Class B soil and 6"(0.50') for a Class C soil. Bioretention systems shall not be permitted in Class D soils.
- The surface area of the Bioretention system shall be determined by the following equation:

SA = (WQv)/hf where:

SA = Surface area of filter bed (square feet)
WQv = Calculated water quality volume (cubic feet)
hf = Depth of ponding above soil surface in feet (use values above per soil class)

TREATMENT:

- The Bioretention facility must fully contain 100% of the required WQv for the contributing area.
- Depth of soil media shall be as specified in Table 7.1.a.
- Soil media shall have a **P-Index** (Phosphorous Index) of 0 – 30 (A low P-Index creates an enhanced environment to remove phosphorous from stormwater)
- Soil Mixture shall consist of sand (85%), Compost (10%), Organic soil (5%) [organic soil shall have no more than 2% clay].
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around plant stems.
- A detailed planting plan shall be provided for each Bioretention system.
- Only native plants shall be used. Appropriate plants for the hydrologic conditions shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the Bioretention system (gravel storage zone, gravel filter course and modified soil mixture).
- The design engineer shall provide an as-built plan of the Bioretention system along with a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of plant material. Dead plants shall be removed and replaced during the first two growing seasons. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2" thick layer around the plant stems.

Bioretention in Parking Islands

The application of Bioretention systems in parking islands is a practical method of addressing Water Quality and Volumetric Reductions for commercial parking facilities. The Bioretention systems shall be installed in parking islands as shown in the picture below. The design parameters stated on page 52 would apply to this application.

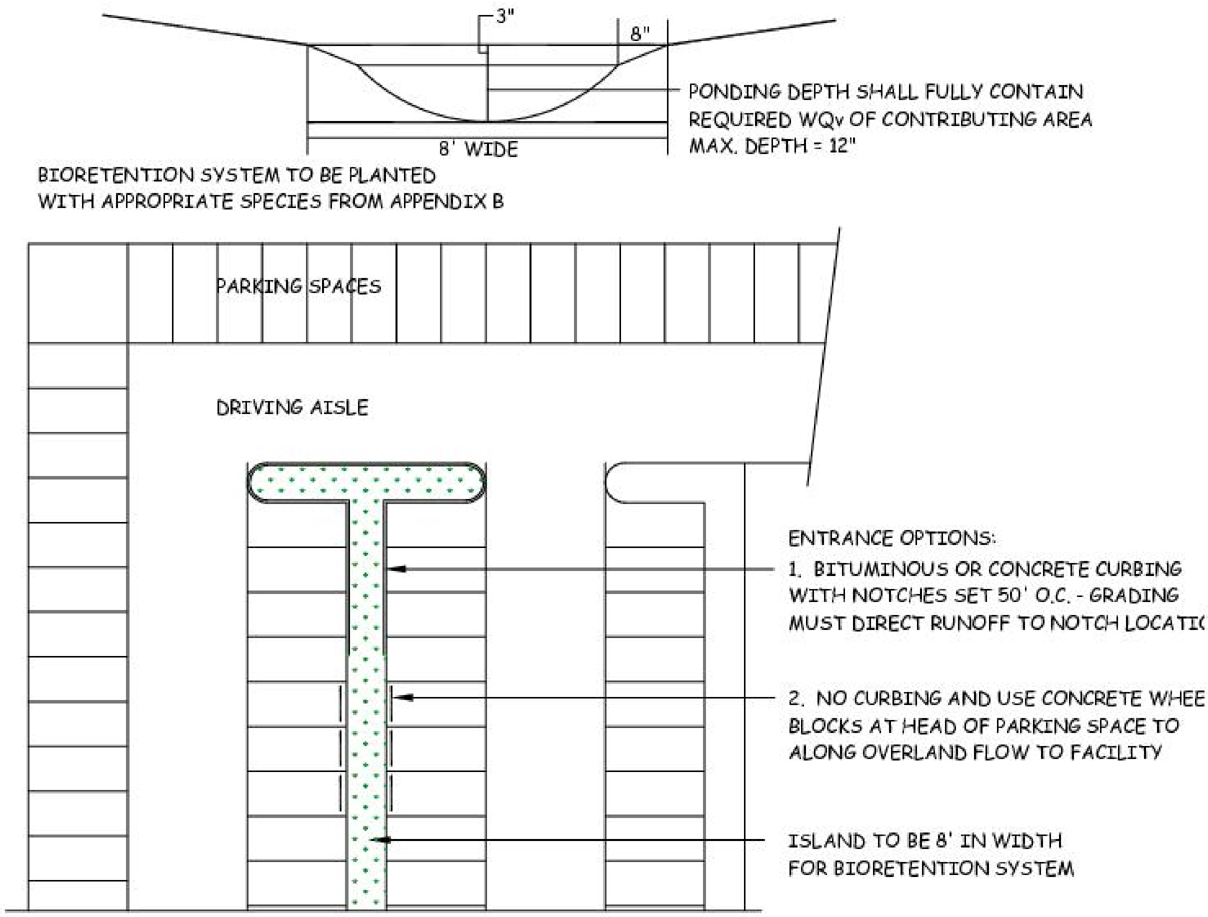


Figure 3.1.c – Bioretention in Parking Islands (Trinkaus Engineering, LLC)

3.2 – TREE FILTER (GRv & WQv)

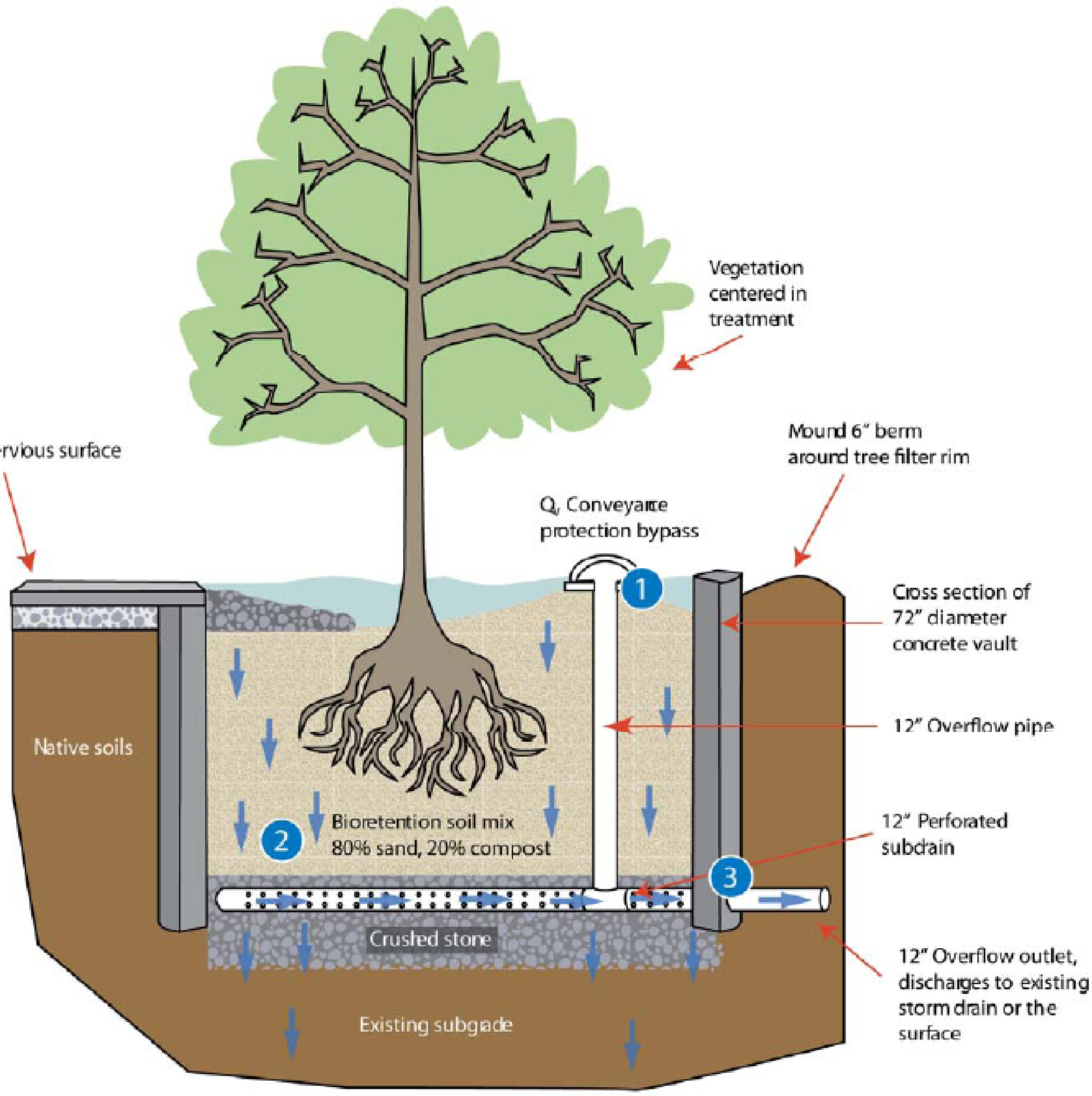


Figure 3.2.a - Tree Filter (UNHSC)

Required Design Elements for Tree Filter Systems

FEASIBILITY:
- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to a tree filter shall be 5,000 square feet (0.12 acres)

CONVEYANCE:
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- At a minimum the underdrain pipe shall consist of 6” perforated PVC pipe. The minimum diameter of the overflow pipe shall be 6”. The overflow pipe shall be sized to convey the Channel Protection Flow for each particular system.

PRETREATMENT:
- No pretreatment is required for a tree filter.

SIZING CRITERIA:
- The maximum permissible ponding depth shall be 12”.
- A minimum surface area for ponding within the tree filter is 36 square feet (6’ x 6’).
- The stone reservoir, consisting of ¾” washed crushed stone (no fines) shall be 24” in depth.

TREATMENT:
- The tree filter system must fully contain 100% of the required WQv.
- Minimum depth of soil mixture shall be 48”.
- Soil Mixture shall consist of sand (80%), and Compost (20%).
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around tree stem.
- Only deciduous tress shall be used. Appropriate tree species shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:
- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the tree filter system (gravel storage zone, and modified soil mixture).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of tree. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2” thick layer around the plant stems.

3.3 - SURFACE SAND FILTER (GRv & WQv)

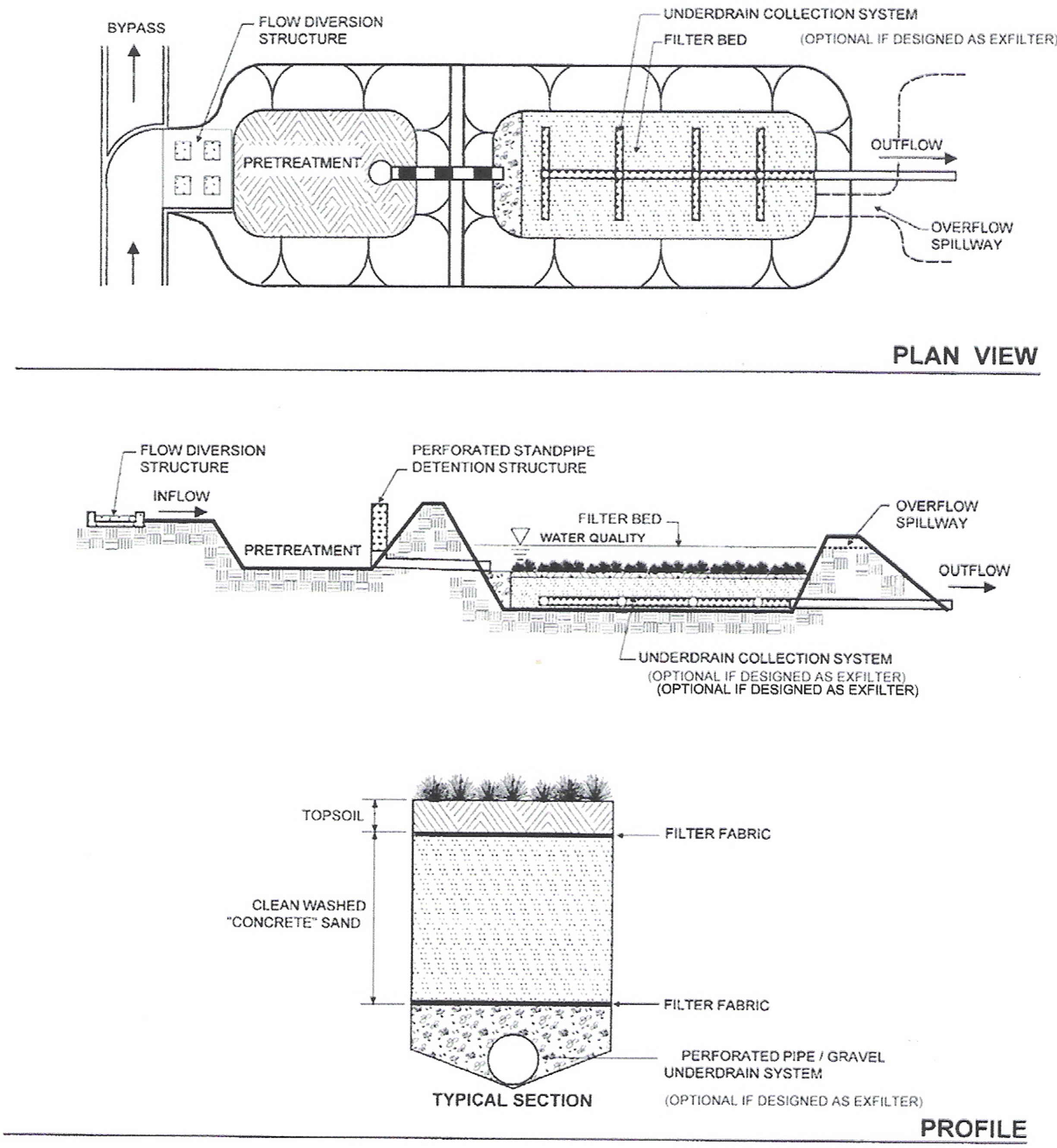


Figure 3.3.a – Surface Sand Filter (RI DEM, 2010)

Required Design Elements for Surface Sand Filters

FEASIBILITY:

- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to a surface sand filter shall be ten (10) acres.

CONVEYANCE:

- Surface sand filter must be designed as “off-line” if stormwater is delivered by standard pipe system.
- Only WQv shall be directed to “off-line” filter with by-pass for larger flows.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- The surface sand filter shall have an underdrain unless it is a fully exfiltrating system.

PRETREATMENT:

- Pretreatment shall be provided by a sediment forebay. The pretreatment area shall provide 25% of the required WQv.

SIZING CRITERIA:

- The surface area of the sand filter shall be determined by the following equation (RI DEM, 2010):

Af = (WQv)*(df)/[(k)*(hr + df)*(tf)] where:

Af = Surface area of filter bed (square feet)
WQv = Calculated water quality volume
df = Filter bed depth (sand media) (feet)
k = Coefficient of sand media, use k=3.5 ft/day
hf = Depth of ponding above soil surface in feet
tf = Design filter bed drain time (days), use tf = 1.0 for surface sand filter

TREATMENT:

- The surface sand filter including the pretreatment component must fully contain 100% of the required WQv. A porosity value of 0.33 shall be used to determine the storage volume within the media. Storage volume within the media can be used to meet the WQv requirement.
- Sand meeting ASTM C-33 specification must be used for filter media.
- Contributing area to surface sand filter must be permanently stabilized prior to directing runoff to filter.
- Minimum depth of sand shall be 24”.
- A minimum diameter of 4” shall be used for the underdrain pipe.
- Surface of sand filter shall be planted with appropriate grass mixture. Grass must be able to sustain periods of frequent drought and inundation. See list in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the sand filter system (gravel storage zone, and sand treatment zone).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Removal of sediment from forebay when accumulated depth is 6”.
- The surface of the filter shall be inspected every six months and trash/debris removed.
- If water is ponding for more than 2.0 days, the surface has likely become clogged with fine sediments. The surface shall be raked to a depth of 2” and reseeded. If clogging still occurs, the top 3” of material shall be removed and replaced with new sand meeting the design specification and reseeded.
- Facilities shall be inspected annually for proper growth of grass material.
- Grass shall be maintained at a height of 3 – 4”.

3.4 - ORGANIC FILTER (GRv & WQv)

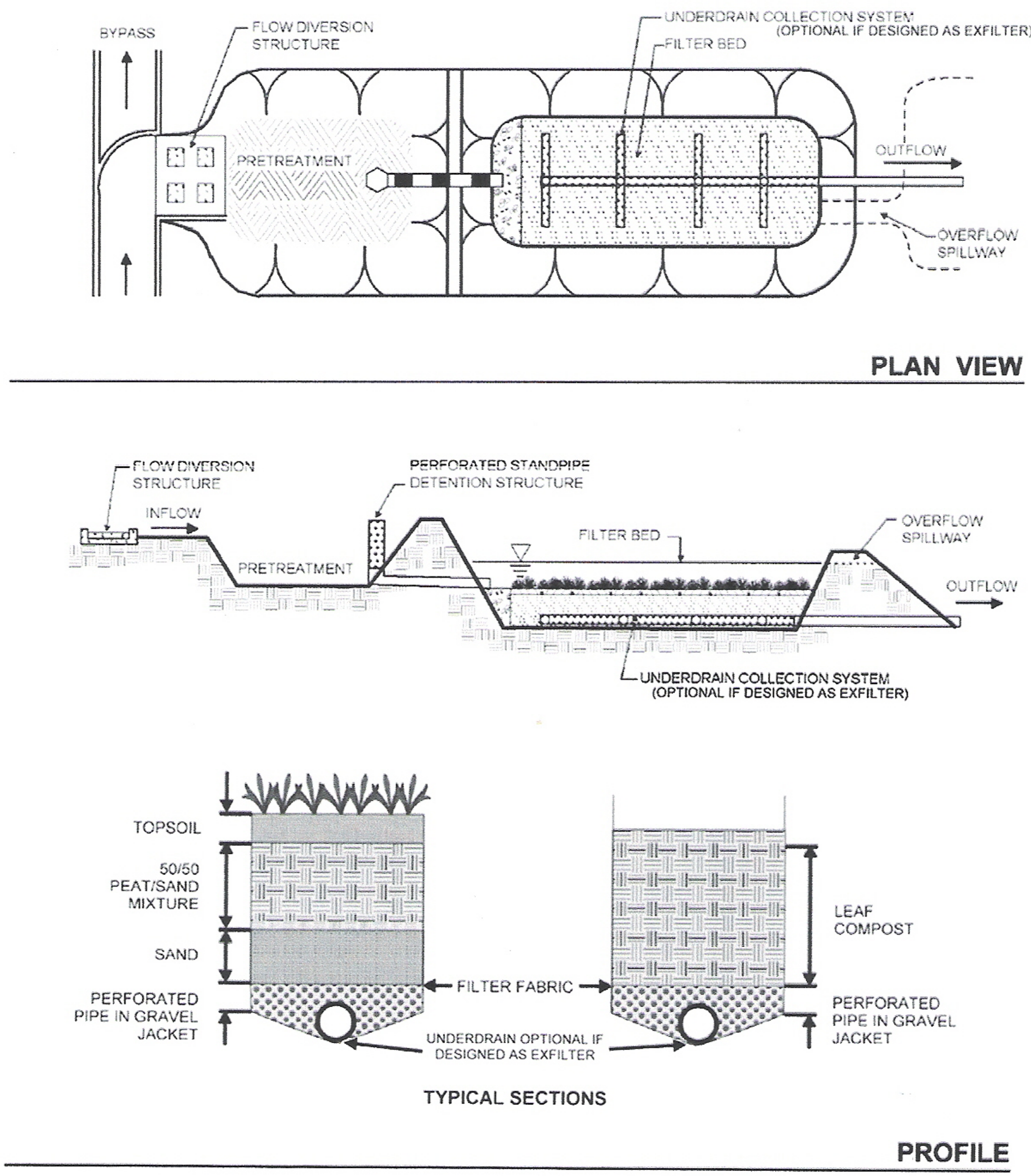


Figure 3.4.a – Organic Filter (RI DEM, 2010)

Required Design Elements for Organic Filters

FEASIBILITY:

- Invert of underdrain pipe (if provided) at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to an organic filter shall be ten (10) acres.

CONVEYANCE:

- Organic filter must be designed as “off-line” if stormwater is delivered by standard pipe system.
- Only WQv shall be directed to “off-line” filter with by-pass for larger flows.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- The organic filter shall have an underdrain unless it is a fully exfiltrating system.

PRETREATMENT:

- Pretreatment shall be provided by a sediment forebay.
- 25% of the required WQv shall be provided by a sediment forebay.

SIZING CRITERIA:

- The surface area of the organic filter shall be determined by the following equation (RI DEM, 2010):

Af = (WQv)*(df)/[(k)*(hr + df)*(tf)] where:

Af = Surface area of filter bed (square feet)
WQv = Calculated water quality volume
df = Filter bed depth (sand media) (feet)
k = Coefficient of sand media, use k=3.5 ft/day, for peat use k = 2.0 ft/day, and for leaf compost, use k = 8.7 ft/day
hf = Depth of ponding above soil surface in feet
tf = Design filter bed drain time (days), use tf = 2.0 for organic filter

TREATMENT:

- The organic filter including the pretreatment component must fully contain 75% of the required WQv. A porosity value of 0.33 shall be used to determine the storage volume within the media. Storage volume within the media can be used to meet the WQv requirement.
- Soil mixture for organic filter shall be either a mix of sand/peat mix or leaf compost. Peat shall be a reed-sedge hemic peat (partially decomposed).
- Contributing area to organic filter must be stabilized prior to directing runoff to filter.
- Minimum depth of media material shall be 24”.
- A minimum diameter of 4” shall be used for the underdrain pipe.
- Surface of organic filter shall be planted with appropriate grass mixture. Grass must be able to sustain periods of frequent drought and inundation. See list in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the organic filter system (gravel storage zone, and media treatment zone).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Removal of sediment from forebay when accumulated depth is 6”.
- The surface of the organic shall be inspected every six months and trash/debris removed.
- If water is ponding for more than 4.0 days, the surface has likely become clogged with fine sediment. The top 6”(minimum) of material shall be removed and replaced with new media meeting the design specification and re-planted.
- Facilities shall be inspected annually for proper growth of grass material.
- The height of vegetation on the surface of an organic filter shall not exceed 18”.

3.5 – DRY SWALES (GRv & WQv)

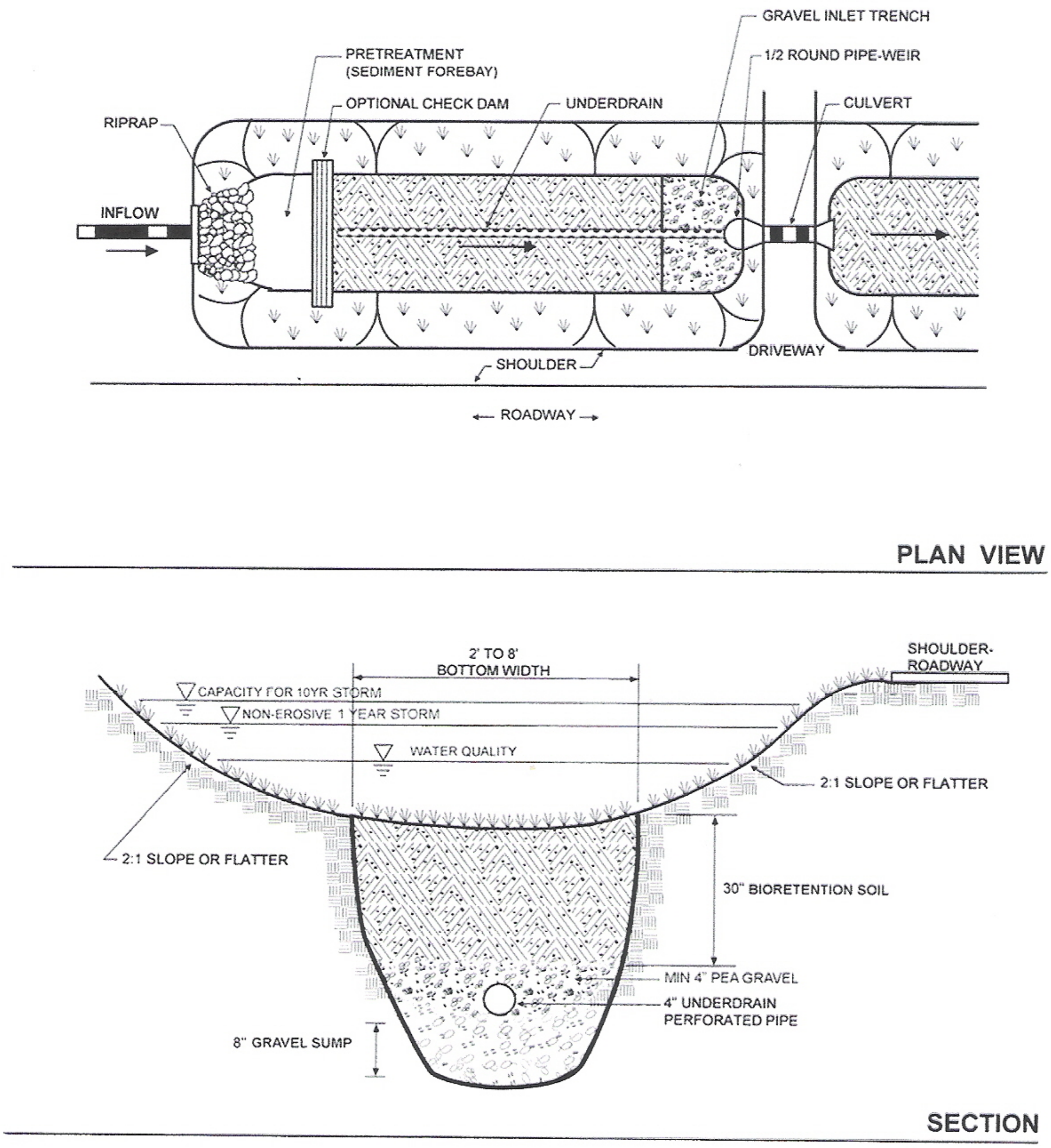


Figure 3.5.a – Dry Swale (RI DEM, 2010)

Required Design Elements for Dry Swales

FEASIBILITY:

- Maximum slope along flow length shall be 4.0% without check dams.
- Invert of underdrain pipe (if provided) or bottom of soil mixture shall be at or above Seasonal High Groundwater (SHGW) level.
- Top of soil surface at least three (3) feet above SHGW.
- The maximum drainage area to a dry swale shall be five (5) acres to one inlet.
- Primary use is along linear systems, such as roads, residential development and pervious areas, such as ballfields.

CONVEYANCE:

- Swale shall be able to handle 10-year, 24-hour peak rate from contributing area.
- Swale side slopes shall be a minimum of 3:1. If there are space constraints, then 2:1 slopes may be used.
- Non-erosive velocities shall be provided (3-5 fps) for 1-year, 24-hour storm event.
- Temporary ponding within the dry swale shall drain within 48 hours. If necessary, an underdrain shall be utilized to achieve this requirement. An underdrain is not required if it is a fully exfiltrating system.

PRETREATMENT:

- Pretreatment shall be required as ponding behind stone check dams located within the swale itself.
- Flow across a vegetated filter strip along a road shall be appropriate pretreatment measure.
- 10% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- The surface area of the filter bed (bottom of swale) shall be determined by the following equation (RI DEM, 2010):

$$Af = (WQv)*(df)/[(k)*(hr + df)*(tf)]$$ where:

Af = Surface area of filter bed (square feet)
WQv = Calculated water quality volume
df = Filter bed depth (sand media) (feet)
k = Coefficient of Bioretention soil mixture (1.0 feet/day)
hf = Average height of water above swale surface (feet)
tf = Design filter bed drain time (days), use tf = 2.0 for dry swale

- Bottom width of swale shall not be greater than eight (8) feet nor less than two (2) feet.

TREATMENT:

- Soil Mixture shall consist of sand (85%), compost (10%), and organic soil (5%) [organic soil shall have no more than 2% clay].
- Appropriate grass mixtures shall be used for the bottom and side slopes of a Dry Swale.
- Contributing area to dry swale must be stabilized prior to directing runoff to filter.
- Minimum depth of Bioretention soil mixture shall be 30”.
- Surface of dry swale shall be planted with appropriate grass mixture. Grass must be able to sustain periods of frequent drought and inundation. See list in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the organic filter system (gravel storage zone, and media treatment zone).
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Shall be inspected annually and after storms greater than 1-year, 24-hour storm event
- Removal of sediment, when accumulation exceeds 25% of the WQv storage value.
- Vegetation shall be mowed as necessary to maintain 4-6” height. Woody vegetation shall be removed from the dry swale.
- If ponded water is regularly observed more than 48 hours after a rainfall event, then the surface shall be roto-tilled to a depth of 12” and reseeded.

3.6 - INFILTRATION TRENCHES (GRv & WQv)

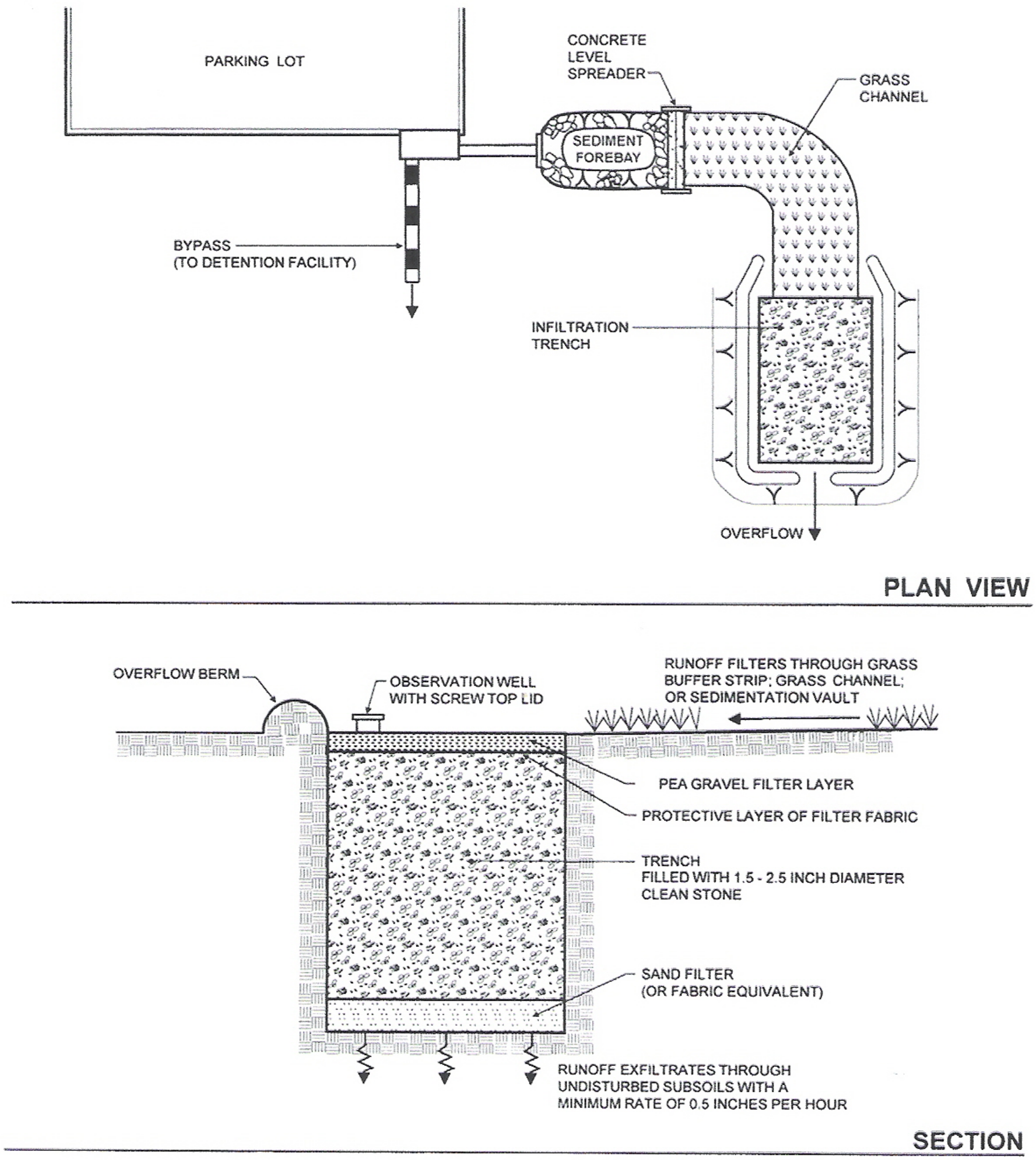


Figure 3.6.a – Infiltration Trench (RI DEM, 2010)

Required Design Elements for Infiltration Trench

FEASIBILITY:

- Three (3) foot vertical separation from bottom of infiltration trench to SHGW and bedrock. For residential applications, this separation can be reduced to two (2) feet.
- Must be installed on slopes < 15% and parallel to contours.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- The maximum drainage area to an infiltration trench shall be five (5) acres.

CONVEYANCE:

- Infiltration trench must be designed as "off-line" if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- All infiltration trenches shall be designed to fully dewater the entire WQv 48 hours after the rainfall event.

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay.
- 25% of the required WQv shall be provided by an appropriate pretreatment system.
- Flow velocities from pretreatment system to infiltration must be non-erosive for 1-yr storm event.
- The sides of the infiltration trench shall be lined with a non-woven filter fabric to prevent soil piping.

SIZING CRITERIA:

- The bottom area of an infiltration trench shall be determined by the following equation (RI DEM, 2010):

$$Ap = V / (ndt = fct/12)$$ where:

Ap = Surface area at the bottom of the trench (square feet)
V = Design volume (WQv) (cubic feet)
n = Porosity of gravel fill (use 0.33)
dt = Trench depth (feet)
fc = Design infiltration rate (in/hr)
t = Time to fill trench (hours), assume t = 2.0

TREATMENT:

- Infiltration trench shall be designed to fully exfiltrate the entire WQv through the bottom of the trench only.
- Design infiltration rates (fc) for above sizing equation shall be taken from the following table.

Table 3.6.a - Design Infiltration Rates for Various Soil Textures (Rawls et al., 1982)

USDA Soil Texture	Design Infiltration Rate (fc) (in/hr)
Sand	8.27
Loamy Sand	2.41
Sandy Loam	1.02
Loam	0.52
Silt Loam	0.27

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- Infiltration trenches shall never be used for sediment control during an active construction period.
- The area of the infiltration trench must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration trench.
- Inspections of an infiltration trench shall be made after any storm greater than the 1-year, 24-hour storm.
- The design engineer shall oversee the preparation of the area and the installation of the stone filter.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

3.7 – INFILTRATION CHAMBERS (GRv & WQv)

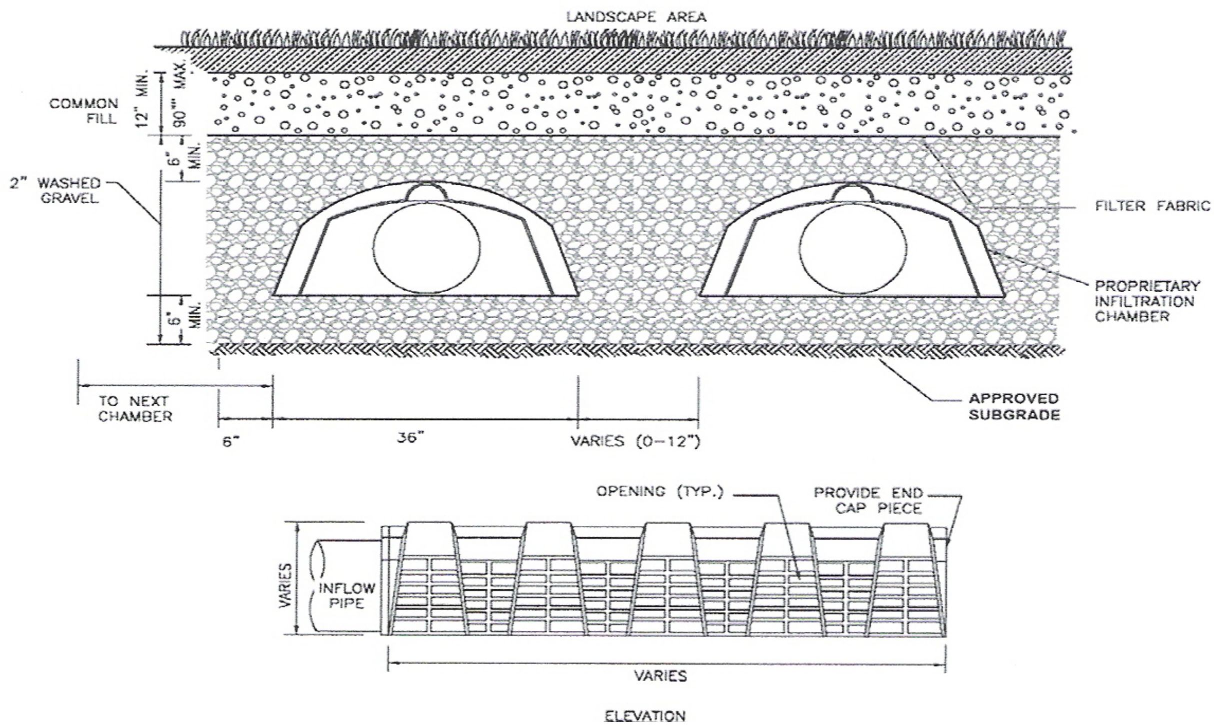


Figure 3.7.a – Infiltration Chamber (RI DEM, 2010)

Table 3.7.a Minimum Setbacks for Infiltration Systems (horizontal measurement in feet) (RI DEM 2010)

	Infiltration Systems for Single Family Residential Uses	Infiltration Systems for all other uses
Public Potable Water Supply Well (Drilled)	200	200
Public Potable Water Supply Well (Gravel well)	400	400
Private Potable Wells	25	100
Potable Water Supply Reservoir	100	200
Streams which are tributary to Water Supply Reservoir	50	100
Other Surface Waters	50	50
Top of 15%+ Slopes	50	50
Buildings (up-gradient)	10	25
Buildings (down-gradient)	10	50
On-site Subsurface Sewage Disposal Systems	25	25

Note: These setback requirements shall apply to Infiltration Trenches, Infiltration Chambers, and Infiltration Basins

Required Design Elements for Infiltration Chambers

FEASIBILITY:

- Three (3) foot vertical separation from bottom of crushed stone under the infiltration chambers to SHGW and bedrock. For residential applications, this separation can be reduced to two (2) feet.
- Must be installed on slopes < 15%.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification.
- The maximum drainage area to infiltration chambers shall be five (5) acres.

CONVEYANCE:

- Infiltration chambers must be designed as “off-line” if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- All infiltration chambers shall be designed to fully dewater the entire WQv 72 hours after the rainfall event.

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay for infiltration chambers. This requirement shall not apply to runoff from a residential roof.
- 25% of the required WQv shall be provided by an appropriate pretreatment system for infiltration chambers.
- The sides of the infiltration chambers shall be lined with a non-woven filter fabric to prevent soil piping.

SIZING CRITERIA:

- One method to calculate the storage volume of manufactured chambers is as follows (RI DEM, 2010):

$$V = L*[(wdn) – (\#Acn) + (\#Ac) + (wfct/12)]$$ where:

V = Design volume (WQv) (cubic feet)
L = Length of infiltration facility (feet)
w = Width of infiltration facility (feet)
d= Depth of infiltration facility (feet)
# = Number of rows of chambers
Ac = Chamber cross sectional area (square feet) (see manufacturers specifications)
n = Porosity (use 0.33)
fc = Design infiltration rate (in/hr)
t = time to fill chambers (use 2 hours for design)

TREATMENT:

- Infiltration chambers shall be designed to fully exfiltrate the entire WQv through the bottom of the facility only.
- Design infiltration rates (fc) for above sizing equation shall be taken from Table 7.6 above.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- Infiltration chambers shall never be used for sediment control during an active construction period.
- The area of the infiltration trench must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration chambers.
- The design engineer shall oversee the preparation of the area and the installation of the infiltration chambers.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

3.8 – INFILTRATION BASIN (GRv & WQv)

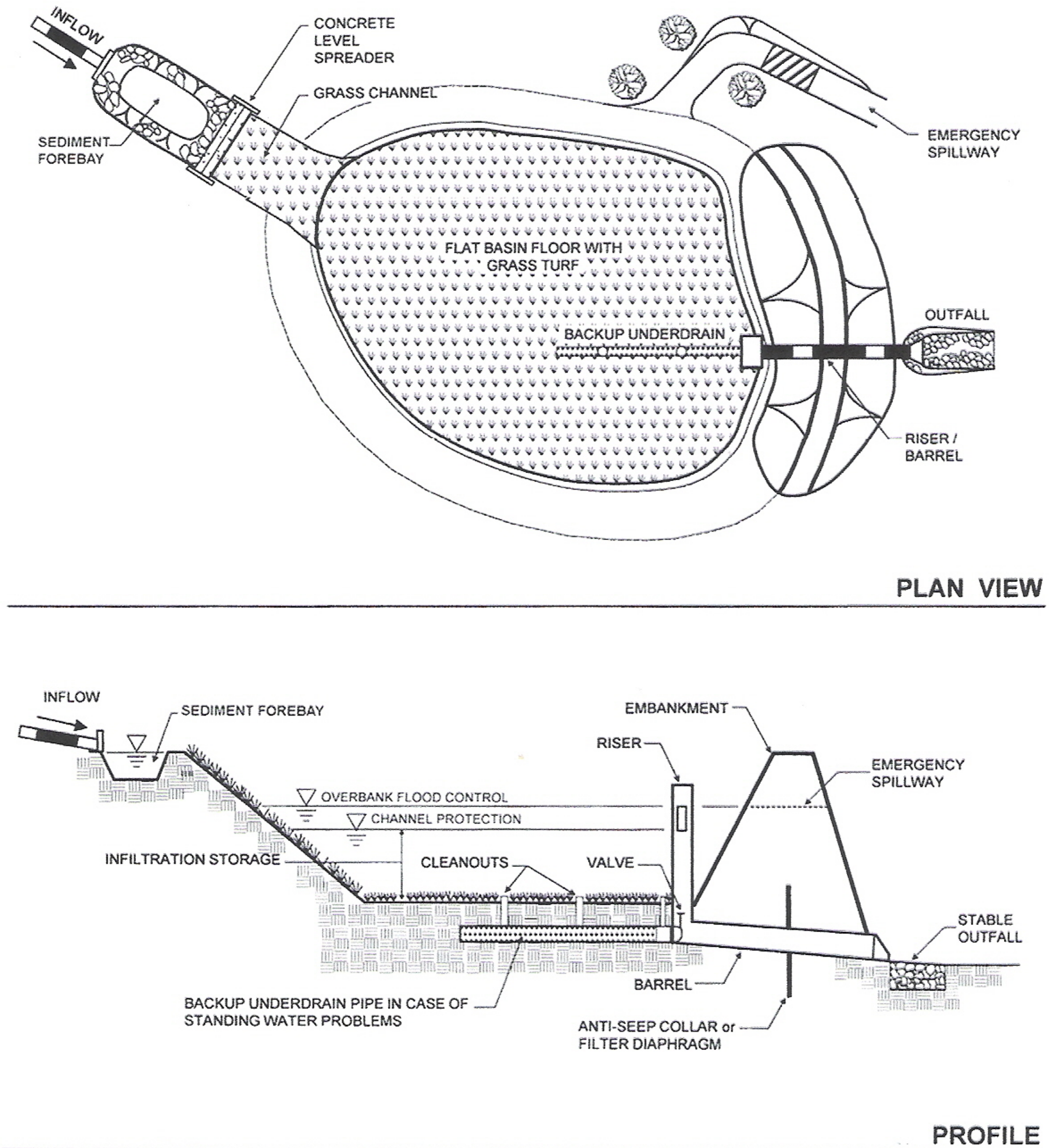


Figure 3.8.a – Infiltration Basin (RI DEM, 2010)

Required Design Elements for Infiltration Basin

FEASIBILITY:

- Three (3) foot vertical separation from bottom of infiltration trench to SHGW and bedrock.
- Must be installed on slopes < 15%.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- The bottom of the infiltration basin shall be constructed in either the A or B soil horizon.
- The maximum drainage area to an infiltration trench shall be ten (10) acres.

CONVEYANCE:

- Infiltration basin must be designed as "off-line" if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).
- Infiltration basins shall be designed to fully dewater the entire WQv 48 hours after the rainfall event.

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps)
- A minimum of 25% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- Maximum ponding depth above soil surface shall be 2'.
- The bottom area of an infiltration basin shall be determined by the following equation:

Ab = V/d Where:

Ab = Surface area at the bottom of the basin (square feet)
V = Design Volume (WQv)
d = Depth of basin (feet)

TREATMENT:

- If the in-situ soil infiltration rate is greater than 8.27 in/hr, then the entire WQv shall be fully treated by an appropriate measure prior to the infiltration basin.
- Infiltration basin shall be designed to fully exfiltrate the entire WQv through the bottom of the basin only.
- Design infiltration rates (fc) for above sizing equation shall be taken from Table 7.6 above.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- Infiltration basins shall never be used for sediment control during an active construction period.
- The area of the infiltration basin must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration basin.
- If there is an accumulation of organic debris or sediment on the surface of the basin, the top 6" shall be removed, and the exposed soil surface roto-tilled to a depth of 12". After this work has been done, the bottom of the basin shall be restored to its original condition.
- Inspections of an infiltration basin shall be made after any storm greater than the 1-year, 24-hour storm.
- The design engineer shall oversee the preparation of the area and the construction of the infiltration basin.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

3.9 – ALTERNATIVE PAVING SURFACES (GRv & WQv)

Refer to UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds – Rev. October 2009 (http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_pa_spec_10_09.pdf)

Open Course Pavers with gravel or topsoil/grass

Required Design Elements for Open Course Pavers

FEASIBILITY:

- Three (3) foot vertical separation from bottom of reservoir base to SHGW and bedrock.
- Use on gentle slope (<5%)
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- The bottom of the reservoir base shall be constructed in either the A or B soil horizon.

CONVEYANCE:

- Open course pavers shall only treat runoff generated from the actual area of the practice. Runoff from adjacent areas shall not to be treated by the open course pavers.
- Open course paver systems shall fully dewater the entire WQv 24 hours after a storm event.

PRETREATMENT:

- Pretreatment is not required for open course pavers.
- Frequent maintenance is required to prevent clogging of the open course pavers.

SIZING CRITERIA:

- The surface area of the open course pavers shall be determined by the following equation (RI DEM, 2010):

$Ap = V / (n8dt + fct/12)$ Where:

Ap = Surface area (square feet)
V = Design volume (WQv) (cubic feet)
n = Porosity of gravel (assume 0.33)
dt = Depth of gravel base (feet)
fc = Design infiltration rate (in/hr), see Table 7.6
t = Time to fill (hours) (use 2 hours for design purposes)

TREATMENT:

- Topsoil mix shall consist of 50% sand, 35% compost and 15% native soils. Alternative surface shall be pea gravel.
- Open course paver systems shall fully exfiltrate the entire WQv through the bottom of the practice.
- The reservoir course shall be 12 – 24" in depth. The base course shall consist of native bank run sand and gravel. It shall be sufficiently compacted to provide the required bearing capacity.
- Area of open course pavers must be protected from compaction and erosion during the construction period.
- This system is best used with other systems to address other stormwater issues such as flood protection.
- Vegetation used with open course pavers shall be drought tolerant species.
- To account for the use of open course pavers in hydrologic models in determining the Channel Protection Flow and Flood Protection Flow rates, the following Curve Number values shall be applied.

Table 3.9.a – Curve Numbers for Infiltrating Permeable Pavement Surfaces (MDE, 2009)

Reservoir Depth (inches)	Hydrologic Soil Group A	B	C	D
6	76	84	93	-
12	62	65	77	-
>12	40	55	70	-

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of open course pavers shall never be used for sediment control during an active construction period.
- The area of the open course pavers must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the open course pavers.
- Attach rollers to bottom of plows to prevent the catching of paver edges during snow removal operations.
- Do not stockpile snow on areas of open course pavers.
- The design engineer shall oversee the preparation of the area and the installation of the alternative paving surface.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

Permeable Pavement or Porous Concrete

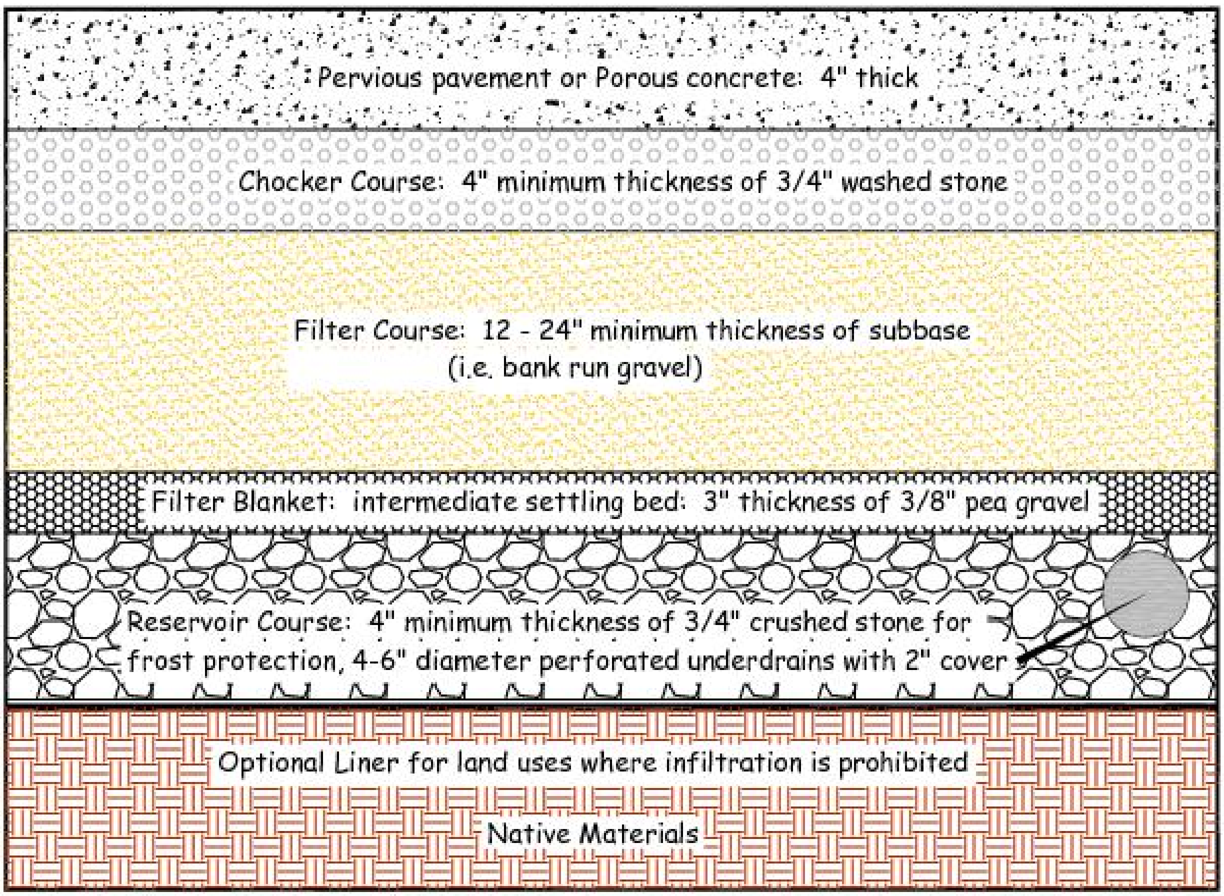


Figure 3.9.a – Permeable Pavement (UNHSC)
Note: Permeable Pavement layer shall be 4" thick
Note: Porous Concrete layer shall be 6" thick

Required Design Elements for Permeable Pavement or Porous Concrete

FEASIBILITY:

- Three (3) foot vertical separation from bottom of reservoir base to SHGW and bedrock.
- Use on gentle slope (<5%)
- Native soils must have an in-situ infiltration rate of 0.5 inches per hour based upon NRCS soil textural classification. Must be verified by field infiltration tests.
- Native soils must have less than 20% clay and 40% silt/clay. This shall be determined by a dry sieve analysis by a qualified soils lab.
- The bottom of the reservoir base shall be constructed in either the A or B soil horizon.

CONVEYANCE:

- Permeable pavement or porous concrete shall only treat runoff generated from the actual area of the practice. Runoff from adjacent areas shall not to be treated by permeable pavement or porous concrete. These systems shall fully dewater the entire WQv 24 hours after a storm event.

PRETREATMENT:

- Pretreatment is not required for permeable pavement or porous concrete.
- Frequent maintenance is required to prevent clogging of the permeable pavement or porous concrete.

SIZING CRITERIA:

- The surface area of the permeable surface shall be determined by the following equation (RI DEM, 2010):

$Ap = V / (n8dt + fct/12)$ Where:

Ap = Surface area (square feet)
V = Design volume (WQv) (cubic feet)
n = Porosity of gravel (assume 0.33)
dt = Depth of gravel base (feet)
fc = Design infiltration rate (in/hr), see Table 4.6
t = Time to fill (hours) (use 2 hours for design purposes)

TREATMENT:

- Permeable pavement or porous concrete shall fully exfiltrate the entire WQv through the bottom of the practice.
- The reservoir course shall be 12 – 24” in depth. The reservoir course shall consist of native bank run sand and gravel. It shall be sufficiently compacted to provide the required bearing capacity. A filter blanket shall be provided between the filter course and the reservoir course.
- An impermeable liner with an underdrain may be provided if underlying soils lack adequate infiltrative capacity for WQv.
- This system is best used with other systems to address other stormwater issues such as flood protection.
- To account for the use of open course pavers in hydrologic models in determining the Channel Protection Flow and Flood Protection Flow rates, see Table 7.9 above.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of permeable pavement or porous concrete shall never be used for sediment control during an active construction period.
- The area of the permeable pavement or porous concrete must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of permeable pavement or porous concrete.
- Every three months, the permeable surface shall be vacuum swept to minimize the potential of clogging.
- Do not stockpile snow on areas of permeable pavement or porous concrete.
- Sand shall not be applied to permeable pavement or porous concrete surface.
- The design engineer shall oversee the preparation of the area and the installation of permeable pavement or porous concrete.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.

3.10 – EXTENDED DETENTION SHALLOW WETLANDS (WQ treatment)

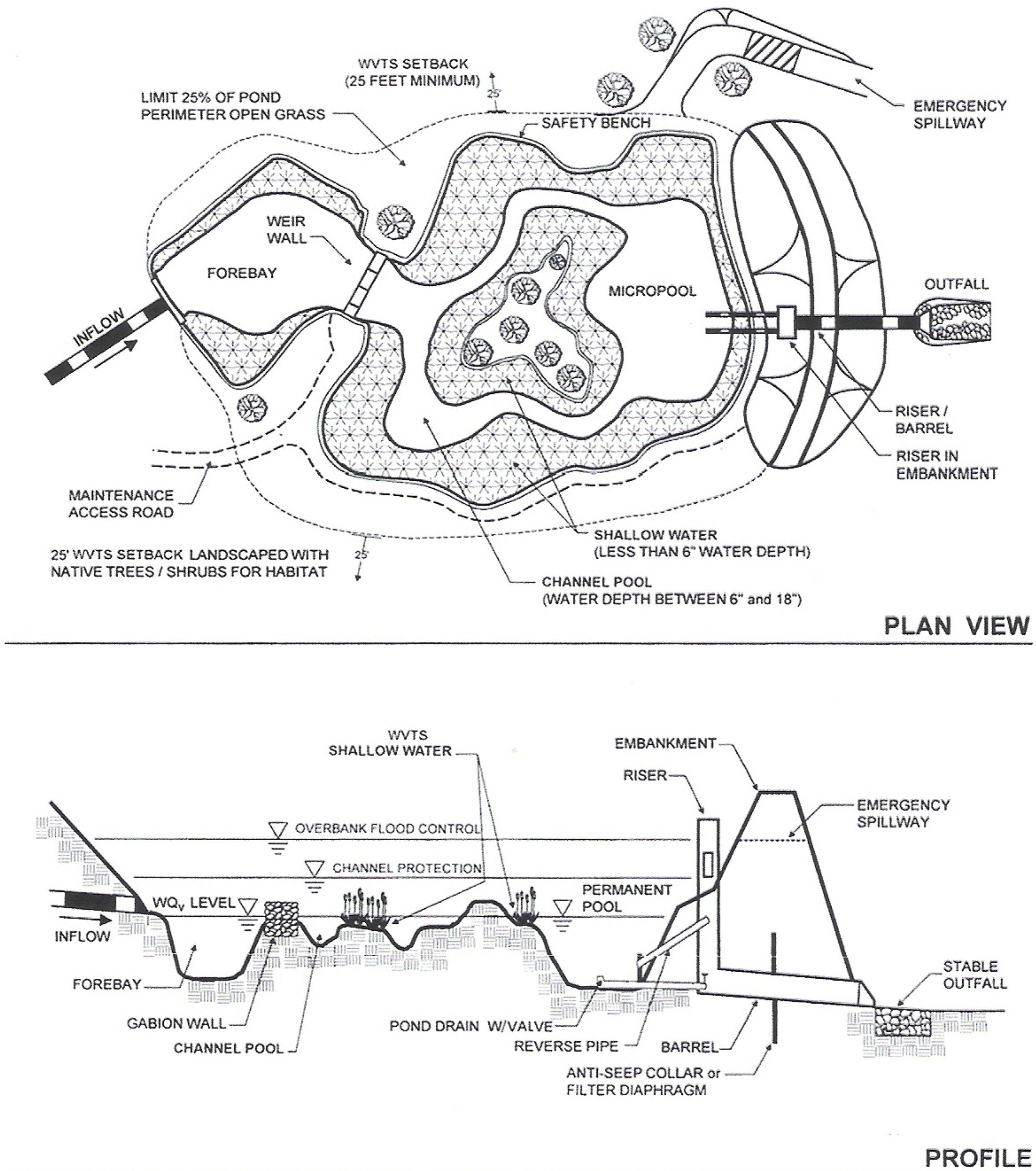


Figure 3.10.a – Extended Detention Shallow Wetland (RI DEM, 2010)

Required Design Elements for Extended Detention Shallow Wetland

FEASIBILITY:

- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in such a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100' linear feet of vegetated surface prior to entering a wetland or watercourse.
- The minimum drainage area to extended detention shallow wetlands shall be ten (10) acres.

CONVEYANCE:

- Flows within the system shall be maximized by the use of islands and submerged berms.
- Discharges from the basin shall be directed toward an established watercourse wherever possible. Appropriately designed outlet protection (2002 Guidelines for Soil Erosion and Sediment Control) shall be provided. The outlet protection shall be sized for the 10-year, 24 hour peak rate discharge.
- Non-erosive velocities shall be provided (3-5 fps) shall be provided for all discharges.

PRETREATMENT:

- A sediment forebay, designed in accordance with the specifications found in Section 8.5 shall be provided for the basin. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by a sediment forebay.
- If there is more than one inlet, then each inlet shall have a sediment forebay.

SIZING CRITERIA:

- The surface area of an extended detention shallow wetland shall be a minimum of 1.5% of the tributary drainage area. Curvilinear configurations shall be used for the basin.
- 65% of the total surface area of the basin shall have a depth of less than 18".
- 35% of the total surface area of the basin shall have a depth of less than 6".
- Deep water areas within the basin shall provide a minimum of 25% of the required WQv, where the depth is greater than 4.0'.
- The minimum length to width ratio shall be 3:1 from inlet to outlet.

TREATMENT:

- If site conditions permit, the extended detention shallow wetland shall be located "off-line". If this is not feasible, then both the Channel Protection Flow and Flood Protection requirements shall be designed into the basin.
- Appropriate vegetation shall be specified for all of the various hydrologic regimes within the basin.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of an Extended Detention Shallow Wetland.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Appropriate access easements for maintenance shall be provided for the basin.
- Inspections of the basin shall be made annually and after all storm events greater than the 1-year, 24 hour event.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Slopes of the basin shall be inspected for erosion and stability on an annual basis. Areas of concern shall be repaired promptly as required.

3.11 - SUBSURFACE GRAVEL WETLANDS (WQ Treatment)

Refer to UNHSC Subsurface Gravel Wetland Design Specifications – June 2009 (http://www.unh.edu/erg/cstev/pubs_specs_info/unhsc_gravel_wetland_specs_6_09.pdf)

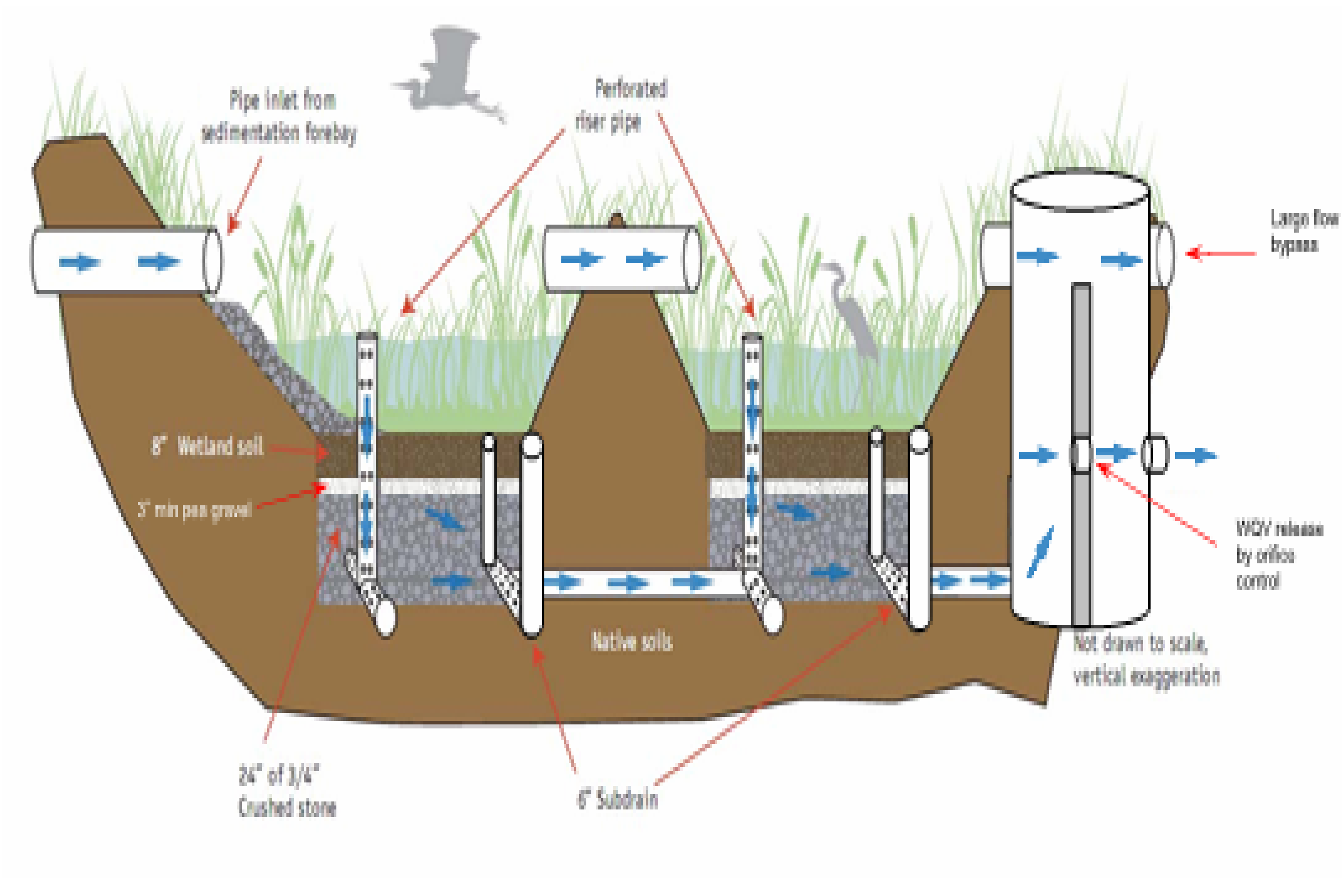


Figure 3.11.a – Subsurface Gravel Wetland (UNHSC)

Required Design Elements for Subsurface Gravel Wetlands

FEASIBILITY:

- Shall be located in soil with low infiltrative capacities or the system bottom & sides shall be lined with impermeable liner or soil with permeability being less than 0.03 ft/day.
- Must be installed on slopes < 5%. Level sites are best.
- The maximum drainage area to an infiltration trench shall be ten (10) acres.

CONVEYANCE:

- Subsurface gravel wetland can be designed as "online" system. System can also provide required Channel Protection Flow above WQv.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).

PRETREATMENT:

- Pretreatment shall be provided with a sediment forebay (Section 7.15).
- Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).

SIZING CRITERIA:

- Forebay provides 10% of the required WQv, each treatment cell provides 45% of the required WQv. The full required WQv must be retained and filtered through the system.
- The invert of primary outlet pipe shall be set 4" below surface of wetland soil to maintain saturated conditions.
- An overflow outlet shall be provided with adequate capacity to handle the peak rate of the 10-year, 24-hour storm event.

TREATMENT:

- Top layer of system is growing media (wetland soil) shall be eight (8) inches in depth with zero slope.
- Intermediate layer is pea gravel three (3) inches thick.
- Treatment layer is 24" in thickness of ¾" crushed stone.
- Berms and weir shall be constructed of non-conductive soils to prevent seepage or piping.
- Length to width ratio for gravel treatment shall be 0.5 (L:W) with a minimum length of fifteen (15) feet.
- Vertical perforated risers shall direct stormwater to treatment layer. Top of vertical riser shall be set at water surface elevation where WQv is provided. Minimum diameter of vertical riser shall be six (6) inches, can be increased to eight (8) inches to minimize clogging potential.
- Vegetation shall consist of obligate and facultative wetland species consisting of grasses, forbs, shrubs.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of a Subsurface Gravel Wetland.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Inspect system to ensure that the ponded water drains down to the soil surface within 24-72 hours after any storm event greater than 1.2" of rain in 24-hours.
- Inspect plants, water plants during 1st year, replace plants as needed, ensure good root establishment across the wetland surface during 1st two years.
- Check stability of slopes during 1st year, repair as needed.
- Inspect inlets, vertical riser pipes and outlet system twice a year.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Remove decaying vegetation, litter and debris.

3.12 – POND / WETLAND SYSTEM (WQ Treatment)

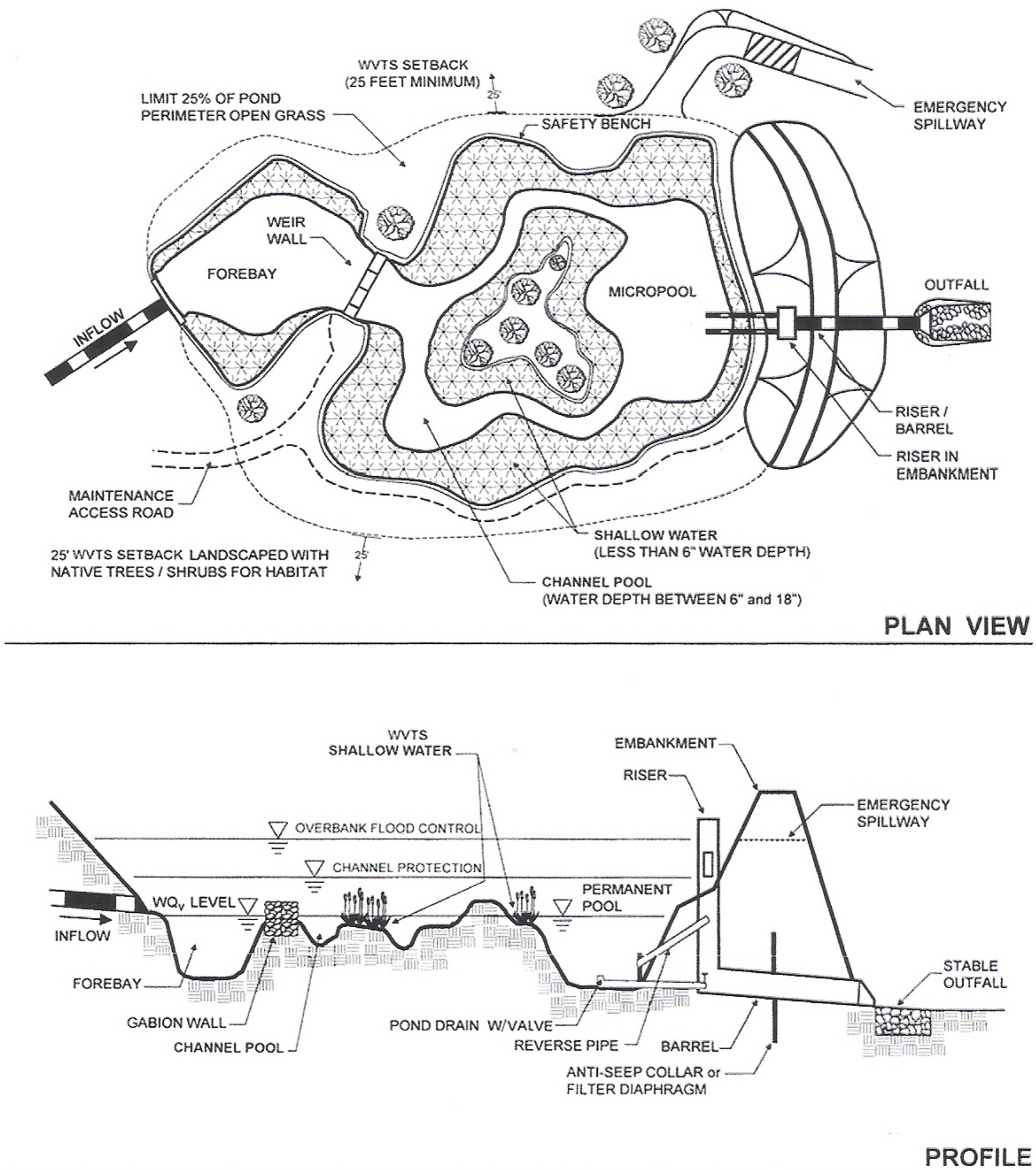


Figure 3.12.a - Pond / Wetland System (RI DEM, 2010)

Required Design Elements Pond / Wetland system

FEASIBILITY:

- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in such a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100' linear feet of vegetated surface prior to entering a wetland or watercourse.
- The minimum drainage area to a pond / wetland system shall be twenty five (25) acres.

CONVEYANCE:

- Flows within the system shall be maximized by the use of submerged berms and microtopography.
- Discharges from the basin shall be directed toward an established watercourse wherever possible. Appropriately designed outlet protection (2002 Guidelines for Soil Erosion and Sediment Control) shall be provided. The outlet protection shall be sized for the 10-year, 24 hour peak rate discharge.
- Non-erosive velocities shall be provided (3-5 fps) shall be provided for all discharges.

PRETREATMENT:

- A sediment forebay, designed in accordance with the specifications found in Section 8.5 shall be provided for the basin. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by a sediment forebay.
- If there is more than one inlet, then each inlet shall have a sediment forebay.

SIZING CRITERIA:

- The surface area of an extended detention shallow wetland shall be a minimum of 1.5% of the tributary drainage area. Curvilinear configurations shall be used for the basin.
- The outlet pool shall also provide a minimum of 10% of the required WQv and shall be 4-6' in depth.
- 35% of the total surface area of the basin shall have a depth of less than 6".
- 50% of the total surface area of the basin shall have a depth of less than 18".
- The minimum length to width ratio shall be 3:1 from inlet to outlet.

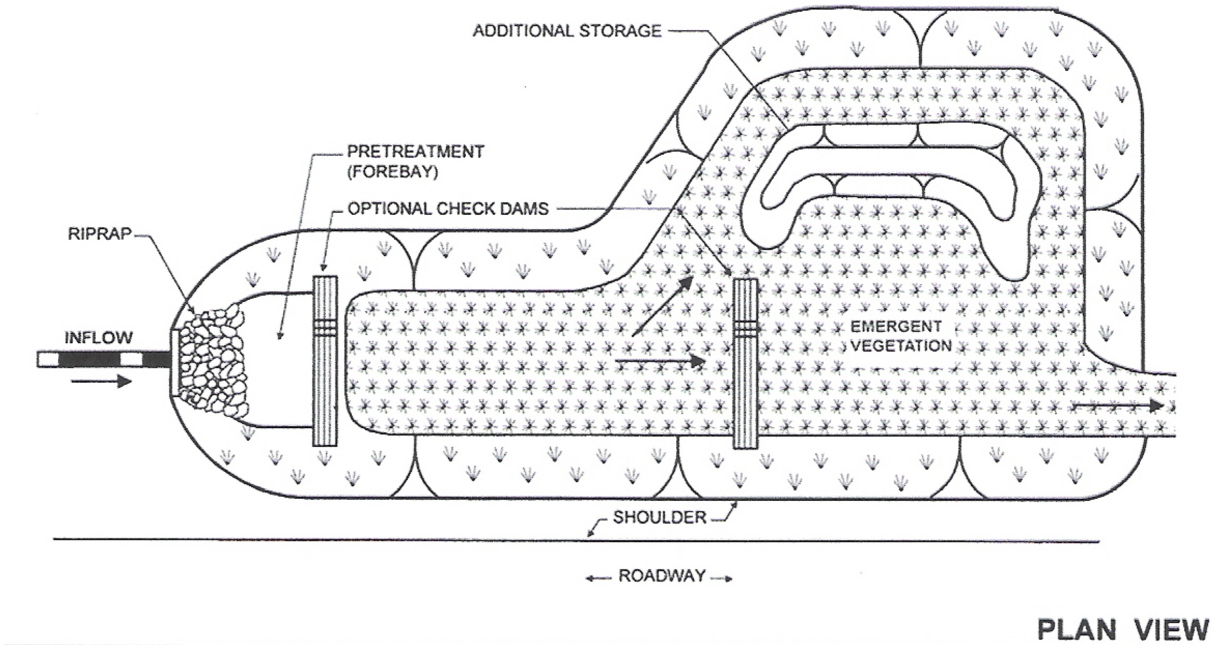
TREATMENT:

- Long, irregular flow paths shall be created by the location and height of the marsh components to increase contact time with vegetation and enhance pollutant removal.
- Appropriate vegetation shall be specified for all of the various hydrologic regimes within the basin.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of a Pond / Wetland System
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Appropriate access easements for maintenance shall be provided for the basin.
- Inspections of the basin shall be made annually and after all storm events greater than the 1-year, 24 hour event for the first year.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Slopes of the basin shall be inspected for erosion and stability on an annual basis. Areas of concern shall be repaired promptly as required.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration basin.
- Vegetation in the basin shall be inspected annually for two growing seasons. Plants shall be replaced during this period as necessary.

3.13 – WET SWALES (WQ Treatment)



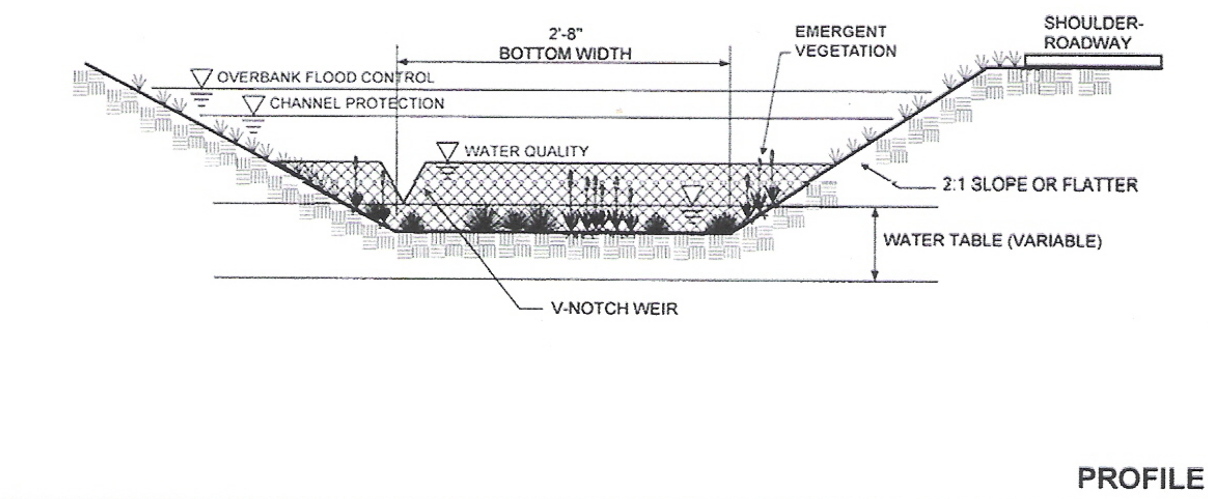


Figure 3.13.a - Wet Swale (RI DEM, 2010)

Required Design Elements for Wet Swales

FEASIBILITY:

- Maximum slope along flow length shall be 4.0% without check dams.
- Wet swales must intercept shallow groundwater level.
- The maximum drainage area to a wet swale shall be five (5) acres.
- Primary use is along linear systems, such as roads, residential development and pervious areas, such as ballfields.

CONVEYANCE:

- Swale shall be able to handle 10-year, 24-hour peak rate from contributing area.
- Swale side slopes shall be a minimum of 3:1. If there are space constraints, then 2:1 slopes may be used.
- Non-erosive velocities shall be provided (3-5 fps) for 1-year, 24-hour storm event.

PRETREATMENT:

- Pretreatment shall be required as ponding behind stone check dams are located within the swale itself.
- Flow across a vegetated filter strip along a road shall be an appropriate pretreatment measure.
- 10% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- The required WQv shall be provided as surface ponding within the wet swale. The length, width and depth shall be designed to achieve this requirement.
- Wet swales shall be designed to provide for a maximum 12" ponded depth.
- Bottom width of swale shall not be greater than eight (8) feet nor less than two (2) feet.

TREATMENT:

- Appropriate emergent plants shall be used for the bottom and side slopes of a wet swale.
- Contributing area to wet swale must be stabilized prior to directing runoff to the wet swale.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of a Wet Swale.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- The Wet Swale shall be inspected annually and after storms greater than 1-year, 24-hour storm event.
- Sediment shall be removed when accumulation exceeds 25% of the WQv storage value.
- Plant shall be inspected annually for 1st two growing seasons. Dead or dying plants shall be replaced as necessary.

3.14 – FILTER STRIPS (Pretreatment)

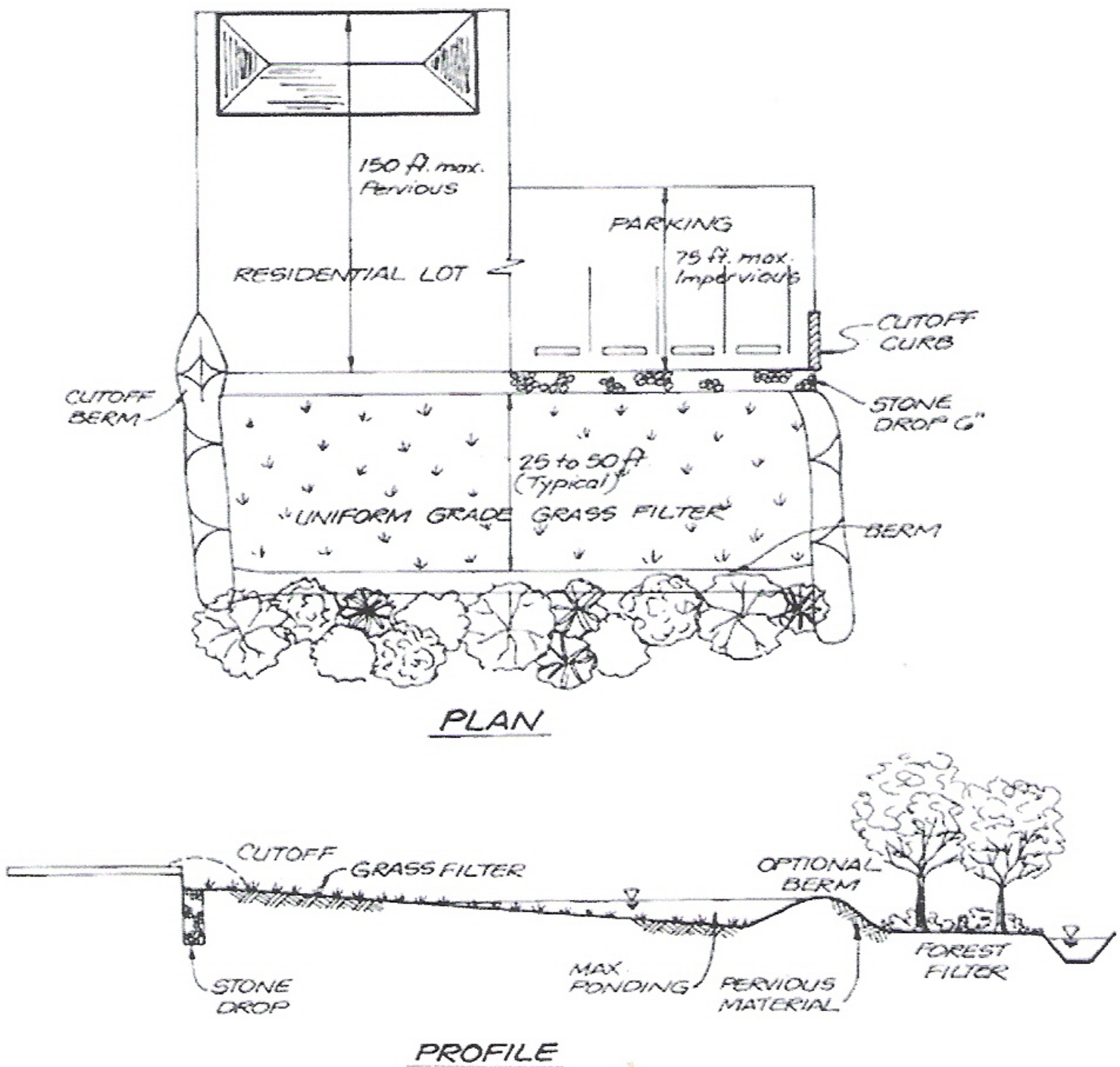


Figure 3.14.a - Filter Strip (RI DEM, 2010)

Required Design Elements for Filter Strip

FEASIBILITY:

- The best application for filter strips is for treating stormwater from roads, small parking areas and roof runoff.
- They can be used as a pretreatment system for other stormwater practices.
- Maximum contributing area to a single filter strip is 0.5 acres.

CONVEYANCE:

- Flows across filter strips must occur as overland flow.
- A stone diaphragm or concrete edge shall be used to ensure uniform overland flow from impervious area.
- If no edge treatment is used, the top of the soil mixture shall be set a minimum of 1" below the pavement edge to allow runoff to "fall off" the impervious edge onto the filter strip.

PRETREATMENT:

- This is a pretreatment system.

SIZING CRITERIA:

- Filter strips shall not be permissible on soils with high clay content.
- Filter strips shall be designed in accordance with the following Table.

Table 3.14.a – Sizing Criteria for Filter Strips

Design Parameter	Impervious Area	Pervious Area
Max. allowable flow length	75'	150'
Filter Strip Slope	4.0%	4.0%
Min. length of filter strip	35'	15'

TREATMENT:

- Sediment is trapped within the grass matrix. If a stone diaphragm is used, this will improve the removal of sediment.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the construction of a Filter Strip.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Grass must become established as soon as possible. If one species does not grow well, it shall be promptly replaced with an alternative species.
- The majority of trapped sediment will occur at the beginning of the filter strip. Sediment shall be removed from this area on an annual basis.
- The area of the filter strip must be marked off by appropriate fencing to prevent the movement of construction vehicles over and the possible compaction of the natural soils.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the filter strip.
- The height of the grass shall be maintained at 4".

3.15 – SEDIMENT FOREBAYS (Pretreatment)

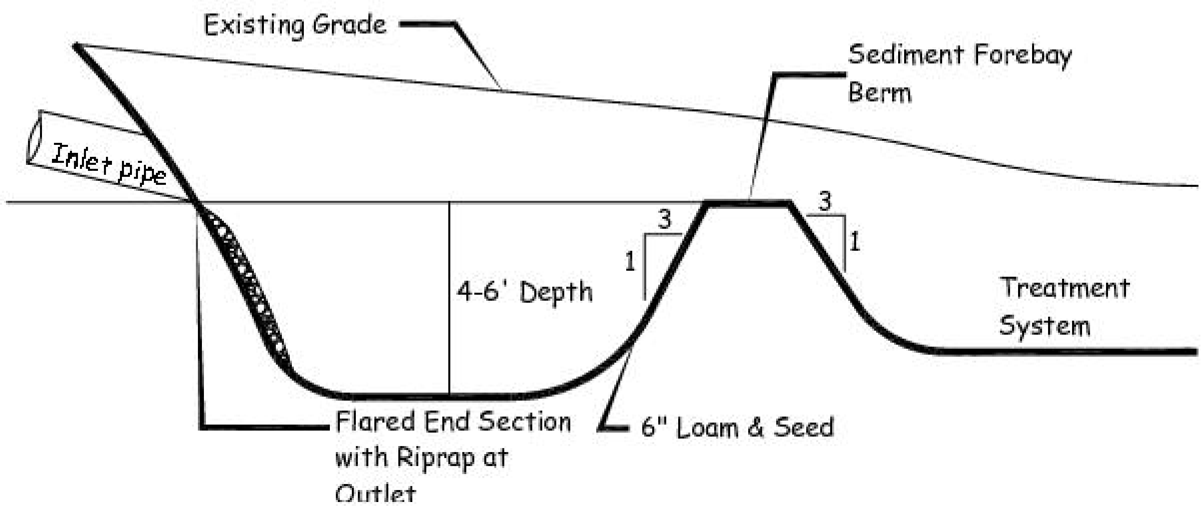


Figure 3.15.a - Forebay (RI DEM, 2010)

Required Design Elements for Sediment Forebay

FEASIBILITY:

- This is a pretreatment practice whose primary purpose is to minimize maintenance requirements of other stormwater treatment systems.
- The sediment forebay shall be made part of another stormwater treatment system and shall not be constructed as a stand alone device.

CONVEYANCE:

- A riprap pad shall be utilized at the inlet to the forebay to reduce flow velocities to non-erosive levels (3-5 fps).

PRETREATMENT:

- This is a pretreatment system for other stormwater management practices.

SIZING CRITERIA:

- A minimum of 10% of the required WQv shall be provided within the sediment forebay.
- The length to width ratio of the sediment forebay shall be 3:1. If site constraints exists this ratio may be reduced to 2:1.
- The forebay shall be a minimum of four (4) feet in depth with a preferred depth of six (6) feet.
- A barrier shall separate the sediment forebay from the treatment facility. The barrier shall be armored as necessary to prevent erosion.
- The invert of the inlet pipe shall be set at the water surface elevation for 10% of the WQv.
- The outlet from the sediment forebay shall be designed in an appropriate manner to convey the flow. This could be a culvert, weir or spillway.
- The outlet elevation must be set, so that the 10% of the required WQv is provided below this elevation.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the preparation of the area and the installation of a sediment forebay.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Access must be provided to the sediment forebay to facilitate removal of accumulated sediments.
- A fixed vertical marker shall be installed in the sediment forebay to allow the depth of sediment to be easily measured and observed.
- The depth of the sediment in the forebay shall be inspected annually and removed when the depth is more than 25% of the total depth of the sediment forebay.

3.16 – DEEP SUMP CATCH BASIN (Pretreatment)

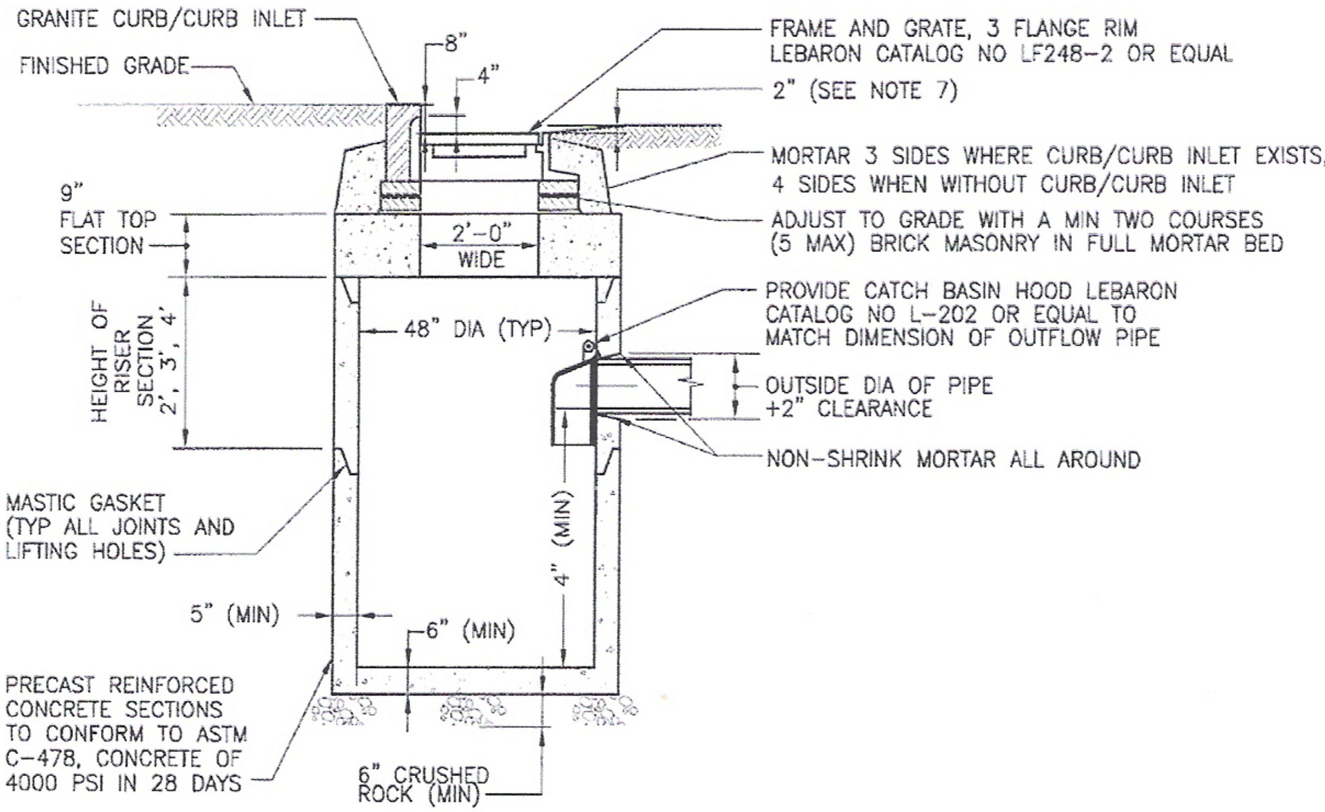


Figure 3.16.a - Deep Sump Catch Basin (RI DEM, 2010)

Required Design Elements for Deep Sump Catch Basins

FEASIBILITY:

- A deep sump catch basin shall be used in a catch basin to manhole alignment as a by-pass.
- The maximum drainage area to a deep sump catch basin shall be 0.5 acres.

CONVEYANCE:

- The deep sump catch basin will see the Water Quality Flow.
- Larger flow rates will by-pass this structure by the utilization of the manhole configuration.
- Hooded outlets shall be used on all deep sump catch basins to trap litter and lighter than water emulsions.

PRETREATMENT:

- This is a pretreatment system.

SIZING CRITERIA:

- The invert of the outlet pipe from a deep sump catch basin shall be set a minimum of four (4) feet above the bottom of the structure.
- The hooded outlet shall be installed in such a manner as to facilitate the easy removal and replacement of the hood.

TREATMENT:

- Coarse grained sediments will settle out in the deep sump.
- Litter and lighter than water emulsions (oils and grease) will be trapped on the water surface by the hooded outlet.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The Design Engineer shall inspect the installed Deep Sump Catch Basin and certify that the required design elements have been provided.
- Inspections shall be made twice a year (fall and spring).
- Sediment shall be removed when it has reached two (2) feet in depth.
- Sufficient access into the structure shall be provided from the grate to facilitate maintenance.

3.17 – OIL/GRIT SEPARATOR (Pretreatment)

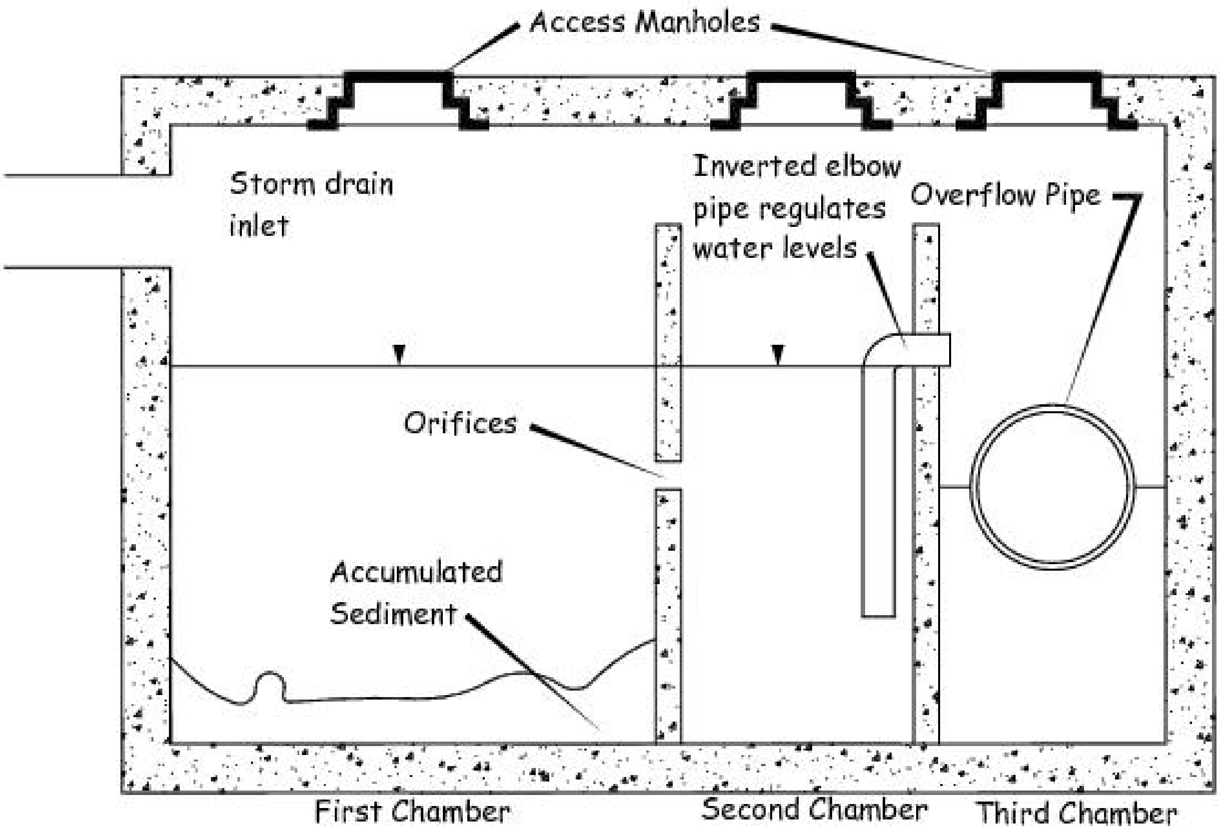


Figure 3.17.a - Oil Grit Separator (Mass Highway 2004)

Required Design Elements for Proprietary Treatment Devices

FEASIBILITY:

- System must be capable of removing a minimum of 25% of Total Suspended Solids to be considered an appropriate pretreatment device. This requirement must be independently verified and supported by necessary written documentation.
- Systems must be designed in accordance with the manufacturer's specifications.
- Contributing area to system shall not exceed one (1) acre of impervious area.

CONVEYANCE:

- System shall be designed as "off-line" to treat full water quality flow. Flows in excess of the water quality flow shall be by-passed around the system.

PRETREATMENT:

- This is a pretreatment device.

SIZING CRITERIA:

- The full water quality flow must be treated by the system.
- A minimum detention time of 60 seconds is required for the water quality flow.

TREATMENT:

- These devices are capable of trapping coarse sediments, litter and lighter than water emulsions by proprietary treatment systems by each manufacturer.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the installation of an Oil Grit Separator.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Maintenance shall be performed in accordance with manufacturer's requirements.
- The devices shall be sited in such a manner as to provide quick, easy access for emergency removal of oils.
- Inspections shall be performed twice a year and cleaned twice a year.
- Debris removed from these systems is considered a hazardous material and must be removed and disposed off by a properly licensed contractor.

3.18 – WET EXTENDED DETENTION POND (Water Quantity Control)

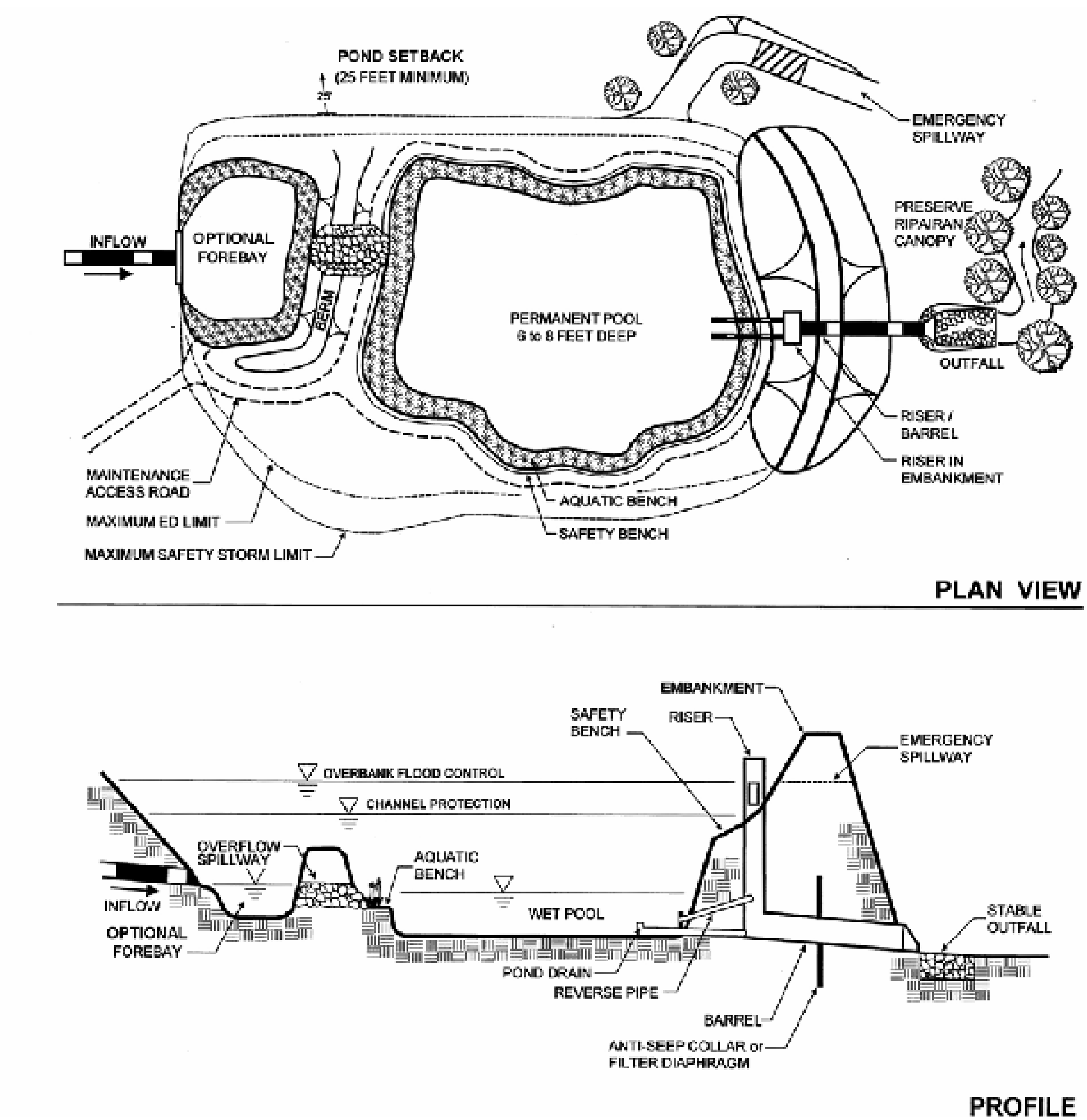


Figure 3.18.a - Wet Extended Detention Pond (RI DEM, 2010)

Required Design Elements for Wet Extended Detention Pond

FEASIBILITY:

- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100' linear feet of vegetated surface prior to entering a wetland or watercourse.
- The minimum drainage area to a Wet Extended Detention Pond shall be twenty five (25) acres.

CONVEYANCE:

- The outlet of the inlet pipe shall be stabilized to provide non-erosive velocities.
- Discharges from the basin shall be directed toward an established watercourse wherever possible. Appropriately designed outlet protection (2002 Guidelines for Soil Erosion and Sediment Control) shall be provided. The outlet protection shall be sized for the 10-year, 24 hour peak rate discharge.
- Non-erosive velocities shall be provided (3-5 fps) for all discharges.
- An emergency spillway, sized to handle the 100-year, 24-hour storm event must be provided.

PRETREATMENT:

- A sediment forebay, designed in accordance with the specifications found in Section 8.5 shall be provided for the basin. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by a sediment forebay.
- If there is more than one inlet, then each inlet shall have a sediment forebay.

SIZING CRITERIA:

- The outlet control system of the wet extended detention pond shall provide for the Channel Protection Flow as well as meet the Flood Protection requirement.
- The wet extended detention pond shall not be considered as a water quality treatment system.
- Water quality treatment shall be provided upstream as an "off-line" system.
- The wet extended detention pond shall utilize curvilinear geometry.
- 65% of the total surface area of the basin shall have a depth of less than 18".
- 35% of the total surface area of the basin shall have a depth of less than 6".
- Deep water areas within the basin shall provide a minimum of 25% of the required WQv, where the depth is greater than 4.0'.
- The minimum length to width ratio shall be 3:1 from inlet to outlet.

TREATMENT:

- If site conditions permit, the extended detention shallow wetland shall be located "off-line". If this is not feasible, then both the Channel Protection Flow and Flood Protection requirements shall be designed into the basin.
- Appropriate vegetation shall be specified for all of the various hydrologic regimes within the basin.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the construction of a Wet Extended Detention Pond.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- Appropriate access easements for maintenance shall be provided for the pond.
- Inspections of the basin shall be made annually and after all storm events greater than the 1-year, 24 hour event.
- It shall be required that sediment is removed from the forebay either every 5 years or when the accumulation of sediment is 50% of the total forebay capacity.
- Slopes of the pond shall be inspected for erosion and stability on an annual basis. Areas of concern shall be repaired promptly as required.
- Inspections of the wet extended detention pond shall be made after any storm greater than the 1-year, 24-hour storm.

3.19 – DRY DETENTION POND (Water Quantity Control)

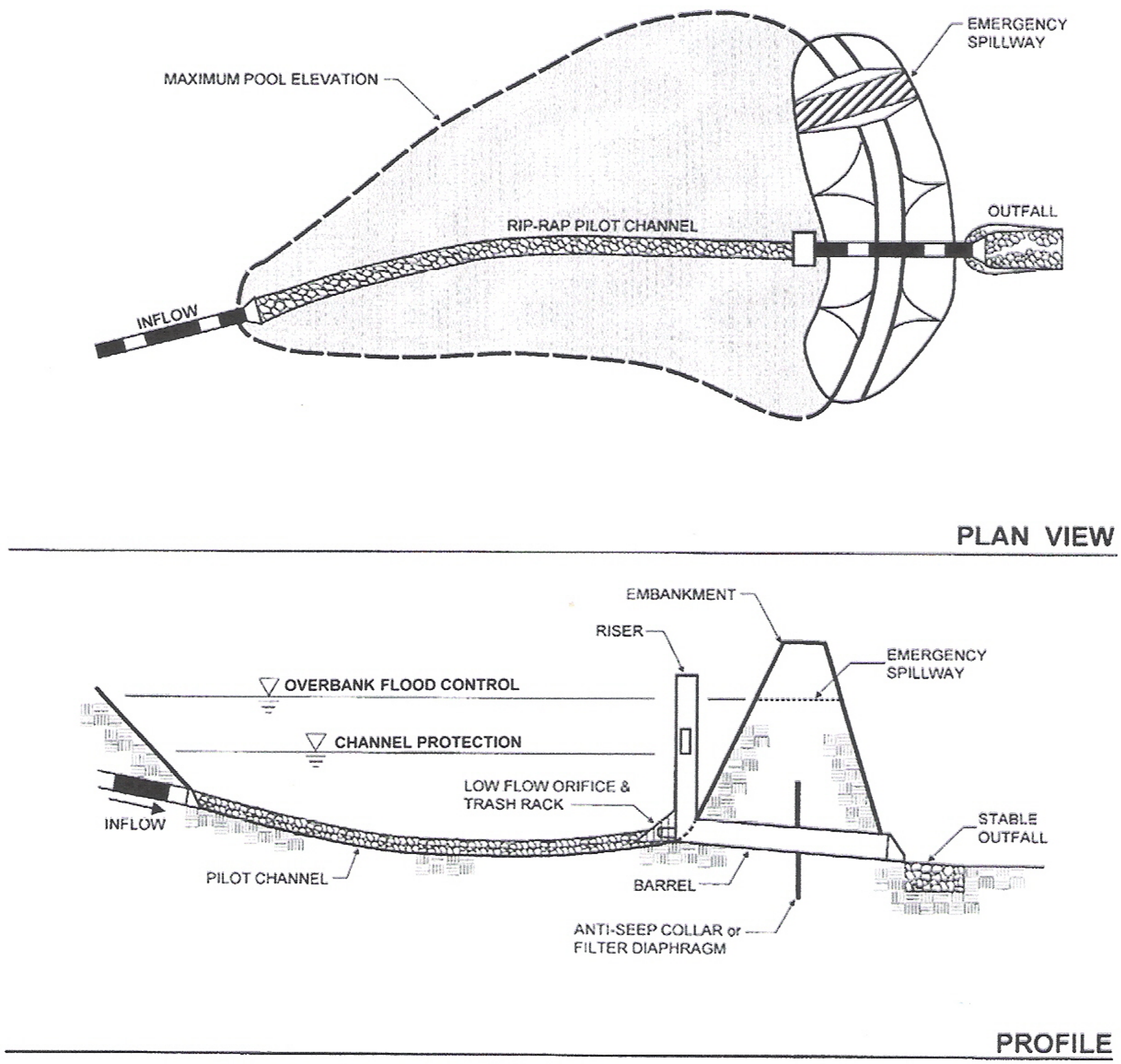


Figure 3.19.a - Dry Detention Pond (RI DEM, 2010)

Required Design Elements for Dry Detention Pond

FEASIBILITY:

- Must be installed on slopes < 15%.
- Shall not be located within limits of delineated inland wetlands and watercourses.
- Siting shall be done in a manner as to maintain the height of the berm over the original grade to less than four (4) feet to avoid classification as a dam.
- Discharge from basin shall be required to travel across a length of 100’ linear feet of vegetated surface prior to entering a wetland or watercourse.
- The maximum drainage area to a dry detention basin shall be twenty five (25) acres.

CONVEYANCE:

- Infiltration basin must be designed as “off-line” if stormwater is delivered by standard pipe system.
- Overflow provisions from the facility shall be provided for the 1-year storm event to either a structural conveyance system or to daylight onto a stable surface, where non-erosive velocities shall be provided (3-5 fps).

PRETREATMENT:

- Pretreatment shall be required as flow across a vegetated filter strip, grass swale or through a sediment forebay. Exit velocities from the pretreatment facility must be non-erosive (3.5 – 5.0 fps).
- A minimum of 10% of the required WQv shall be provided by an appropriate pretreatment system.

SIZING CRITERIA:

- The storage capacity of a dry detention pond shall be sufficient to detain the increases in the peak rate of runoff for the 10-year, 24-hour storm and potentially the 100-year, 24-hour storm event as necessary.

TREATMENT:

- A dry detention pond is used for water quantity control only.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The design engineer shall oversee the installation of a Dry Detention Pond.
- The design engineer shall provide a certification that the system was designed in accordance with the specifications found in the Design Manual and constructed in accordance with the approved plans.
- A dry detention pond can be used for sediment control during an active construction period.
- The erosion control plan for the project must clearly define how sediment will be prevented from entering the area of the infiltration basin.
- If there is an accumulation of organic debris or sediment on the surface of the basin, it shall be removed and the area reseeded.
- Inspections of a dry detention basin shall be made after any storm greater than the 2-year, 24-hour storm.

3.20 – LID URBAN PLANTER (Commercial Retrofit)

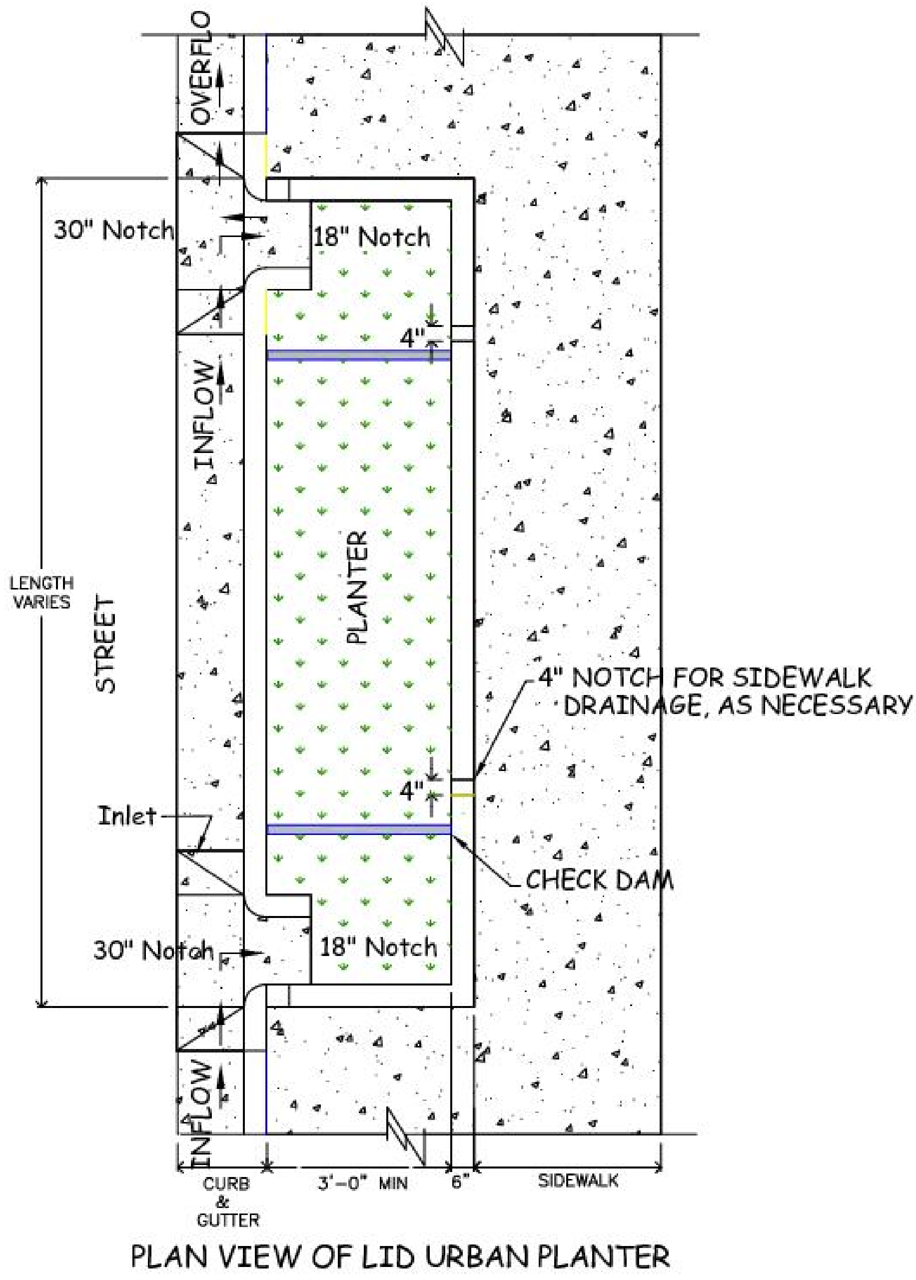


Figure 3.20.a – LID Urban Planter (City of Portland, OR)

Required Design Elements for LID Urban Planter

FEASIBILITY:

- Must be installed on slopes < 5%.
- Shall not be located closer than ten (10) feet to the foundation of a building, unless the system is lined with an impermeable liner.
- The maximum drainage area to a LID Urban Planter shall be 10,000 square feet (0.22) acres.

CONVEYANCE:

- Conveyance to a LID Urban Planter shall be via notches installed in the existing curb along the pavement edge as shown.
- An overflow pipe shall be installed in the system that will provide a freeboard of 4" prior to overtopping the curb height.

PRETREATMENT:

- No pretreatment is required.

SIZING CRITERIA:

- At least 50% of the required water quality volume (WQv) of the drainage area shall be provided as fixed storage with the LID Urban Planter.
- The surface area of the bottom of the LID Urban Planter system shall be determined by the following equation:

SA = (WQv)*(.50)/hf where:

SA = Surface area of filter bed (square feet)
WQv = Calculated water quality volume (cubic feet)
hf = Depth of maximum ponding above soil surface in feet (0.67')

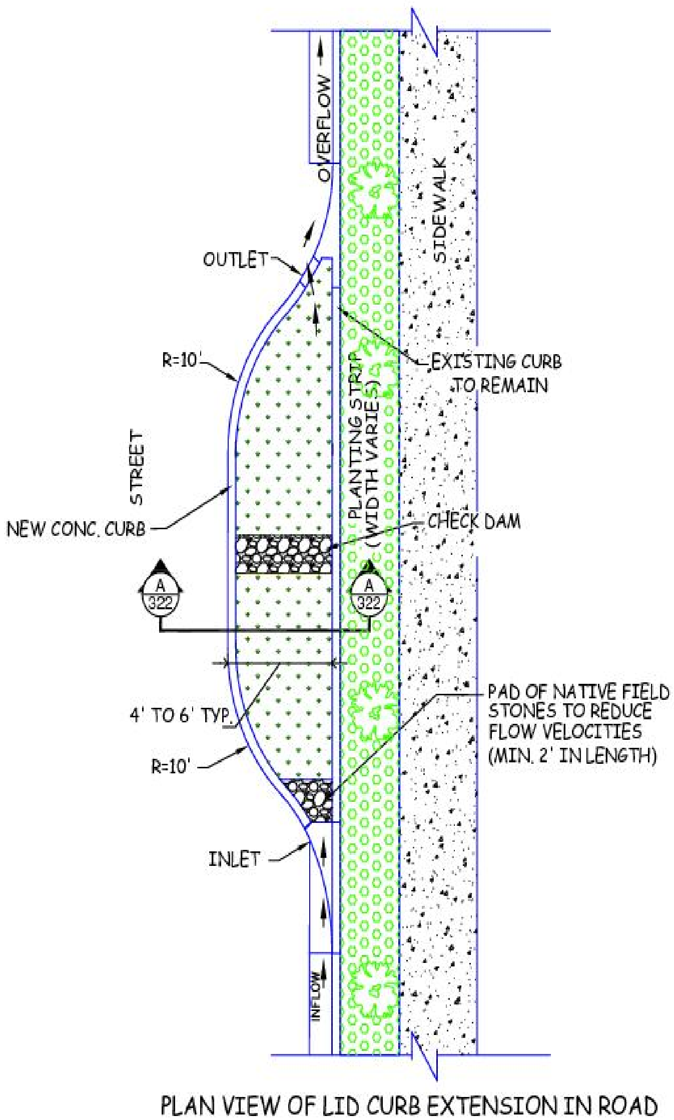
TREATMENT:

- Minimum depth of soil mixture shall be 18". The maximum depth shall be 24"
- Soil Mixture shall consist of sand (85%), compost (10%), and organic soil (5%) [organic soil shall have no more than 2% clay].
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around plant stems.
- A detailed planting plan shall be provided for each LID Urban Planter system.
- Only native plants shall be used. Appropriate plants for the hydrologic conditions shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the LID Urban Planter system (gravel storage zone, gravel filter course and modified soil mixture).
- The design engineer shall provide an as-built plan of the LID Urban Planter system along with a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of plant material. Dead plants shall be removed and replaced during the first two growing seasons. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2" thick layer around the plant stems.

3.21 – LID CURB EXTENSION (Commercial Retrofit)



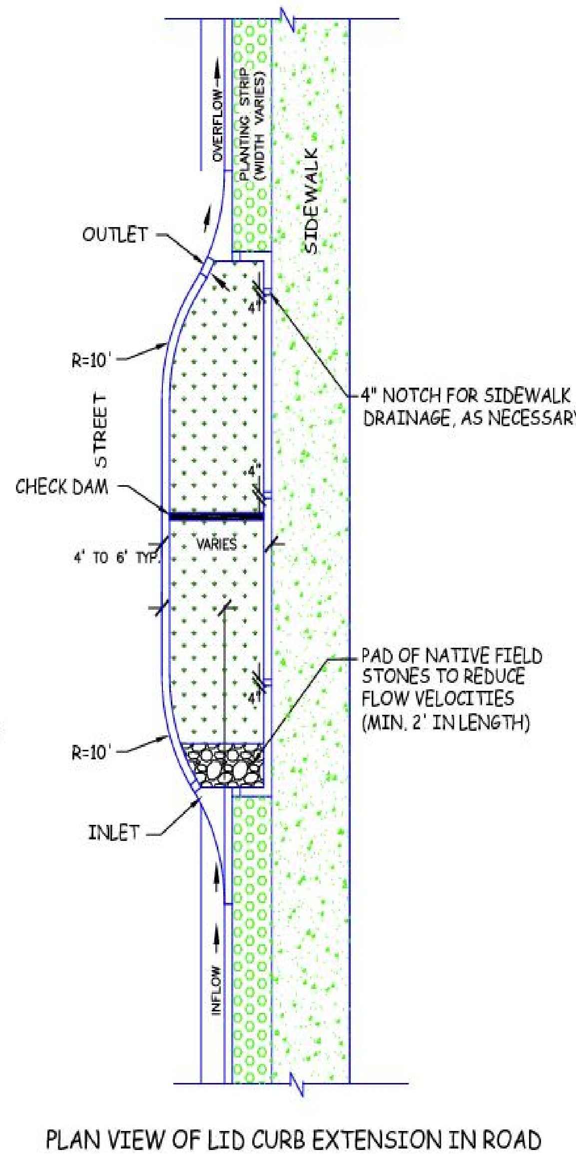
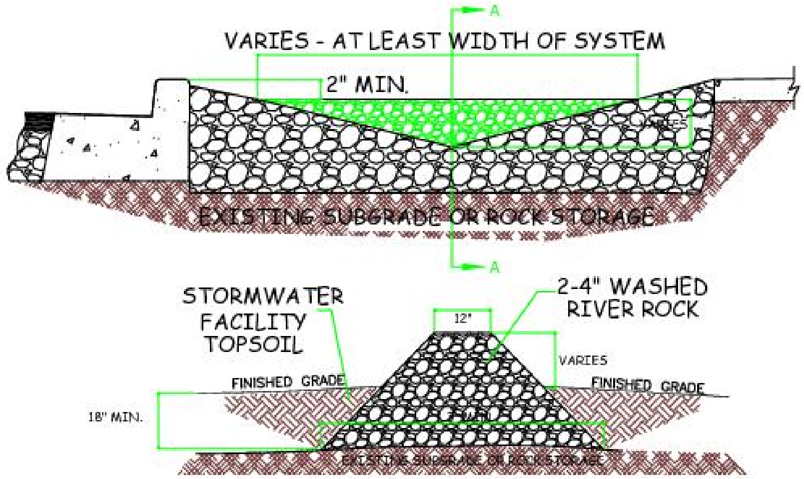


Figure 3.21.a – LID Curb Extension (City of Portland, OR)



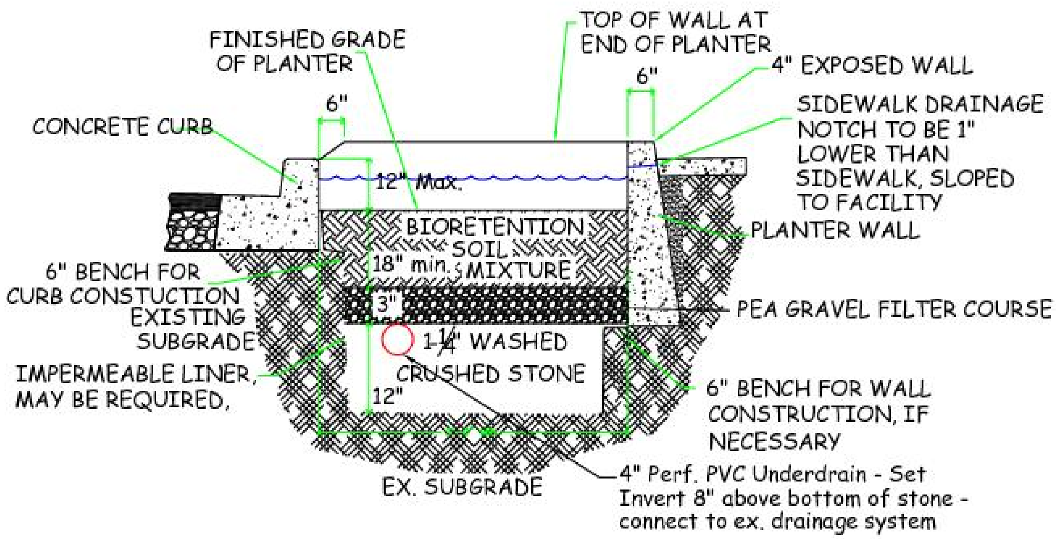


Figure 3.21.b – Cross Section of LID Curb Extension / LID Urban Planter (City of Portland, OR)

Required Design Elements for LID Curb Extensions

FEASIBILITY:

- Must be installed on slopes < 5%.
- Must not interfere with existing underground utilities.
- The maximum drainage area to a LID Urban Planter shall be 0.5 acres.

CONVEYANCE:

- Conveyance to a LID Curb Extension shall be via a new inlet located on the existing gutter line of the street.
- An outlet shall discharge larger storm flow back to the existing gutter line.

PRETREATMENT:

- No pretreatment is required.

SIZING CRITERIA:

- At least 10% of the required water quality volume (WQv) of the drainage area shall be provided as fixed storage with the LID Urban Planter.
- Stone check dams shall be constructed as needed to provide the required storage water quality volume.
- The surface area of the bottom of the LID Curb Extension system shall be determined by the following equation:

SA = (WQv)*(0.10)/hf where:

SA = Surface area of filter bed (square feet)
WQv = Calculated water quality volume (cubic feet)
hf = Depth of maximum ponding above soil surface in feet (0.5')

TREATMENT:

- Minimum depth of soil mixture shall be 18". The maximum depth shall be 24"
- Soil Mixture shall consist of sand (85%), compost (10%), and organic soil (5%) [organic soil shall have no more than 2% clay].
- Mulch layer shall consist of well aged (6-12 month old) shredded hardwood mulch and shall only be placed around plant stems.
- A detailed planting plan shall be provided for each LID Curb Extension system.
- Only native plants shall be used. Appropriate plants for the hydrologic conditions shall be taken from the plant lists found in Appendix B.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The area of the facility shall be fenced off during the construction period to prevent disturbance of the soils.
- The design engineer shall oversee the preparation of the area and the installation of the various components of the LID Curb Extension system (gravel storage zone, gravel filter course and modified soil mixture).
- The design engineer shall provide an as-built plan of the LID Curb Extension system along with a certification that the system was designed in accordance with the specifications found in the Design Manual and installed in accordance with the approved plans.
- Facilities shall be inspected annually for proper growth of plant material. Dead plants shall be removed and replaced during the first two growing seasons. Plants shall be pruned as needed.
- Mulch shall be reapplied as needed to maintain a 2" thick layer around the plant stems.

3.22 – MODULAR WETLAND SYSTEM (Commercial Retrofit)

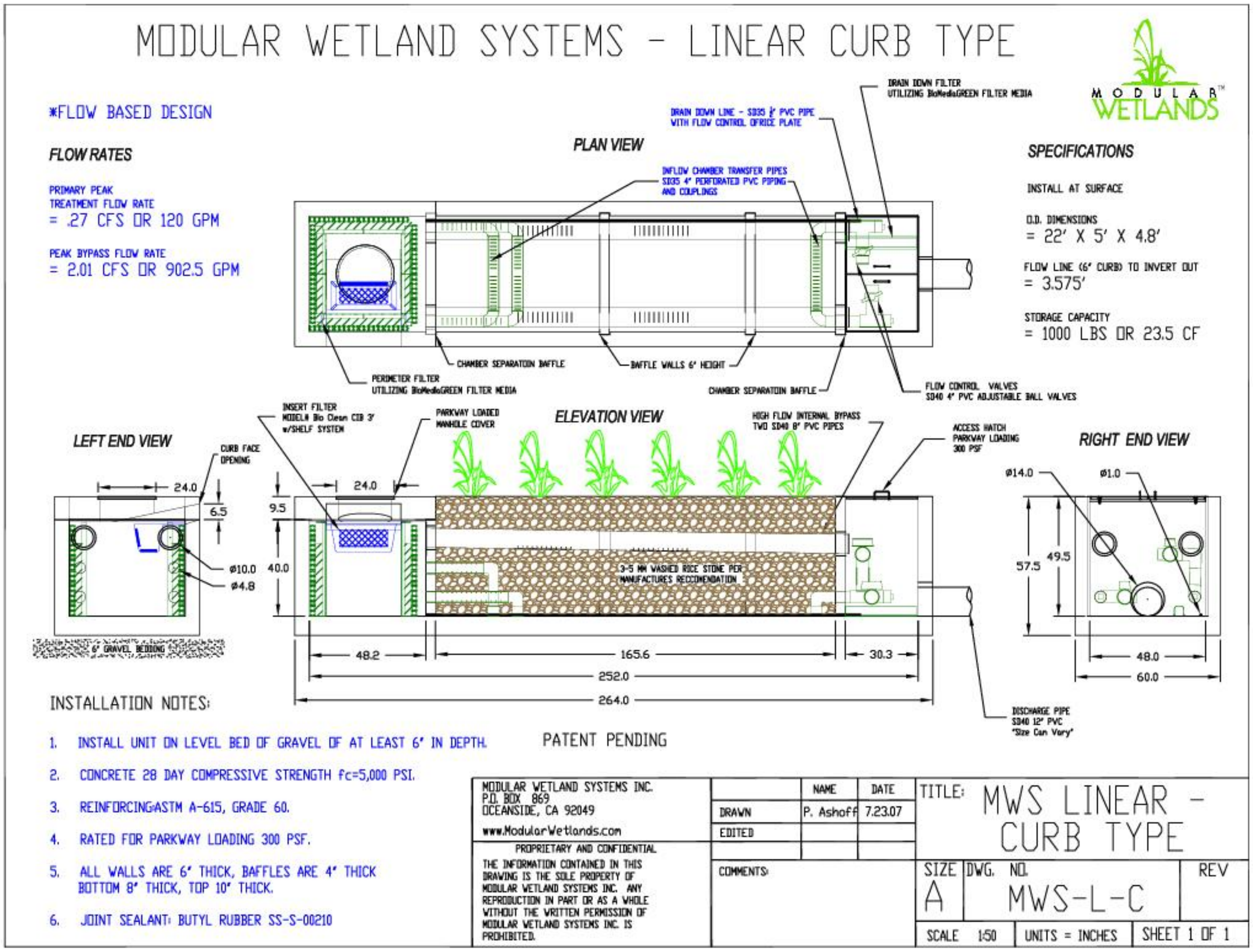


Figure 3.22.a – Modular Wetland System (Modularwetlands.com)

Required Design Elements for Modular Wetland

FEASIBILITY:

- Must be installed on slopes < 5%.
- Must not conflict with existing underground utility lines.
- Outlet pipe shall connect to existing stormwater conveyance system in the stream
- The maximum drainage area shall be 2 acres, unless sizing calculations will demonstrate that the system can handle a larger area.

CONVEYANCE:

- Conveyance to the system is by a field inlet structure that is an integral part of the treatment structure.

PRETREATMENT:

- Pretreatment is provided in the inlet structure of the modular wetland system.

SIZING CRITERIA:

- The Modular Wetland system may be sized for either the Water Quality Flow or the Water Quality Volume.
- Sizing calculators are available online at www.modularwetlands.com for this purpose.

TREATMENT:

- The Modular Wetlands provides filtration, sedimentation and biological uptake to remove pollutants from stormwater.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The Modular Wetland System must be installed in accordance with all the specifications provided by the manufacturer. (www.modularwetlands.com)
- Clean screening filter device a minimum of twice a year (15 minute service time).
- Clean separation (sediment) chamber once a year (30 minute service time).
- Evaluate primary filtration media on an annual basis and replace primary filtration media (BioMediaGREEN blocks) as needed.
- Evaluate condition of wetland media on annual basis. Replacement of media may need to occur once every 5 to 20 years depending upon pollutant loads.
- Replace drain down filter media (BioMediaGREEN blocks) once a year (5 minute service time).
- Trim vegetation as needed (15 minute service time).

3.23 – FILTERRA BIORETENTION SYSTEM (Commercial Retrofit)

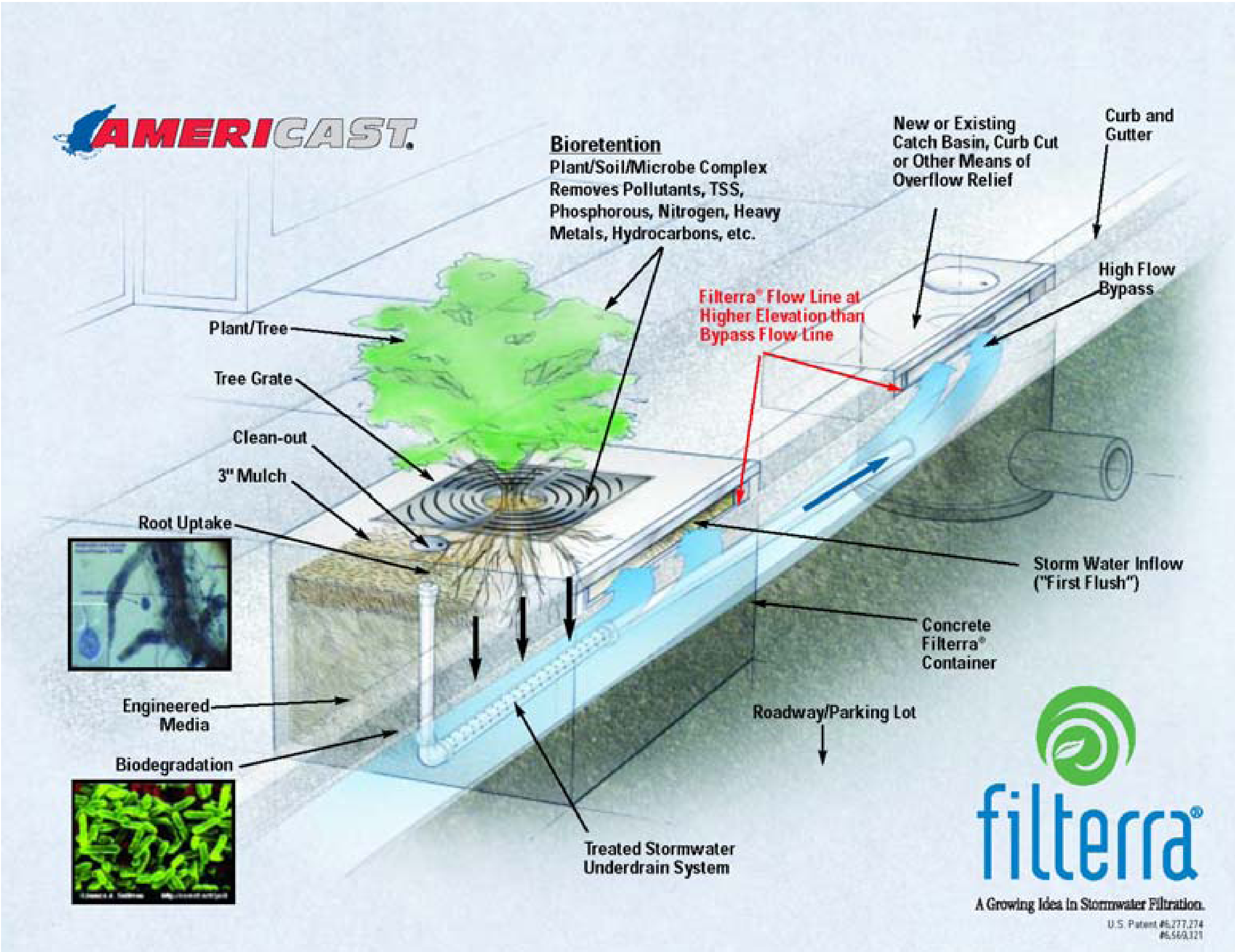


Figure 3.23.a – Filterra Bioretention (Filterra.com)

Effective Date: 2/4/12

Required Design Elements for Filterra Bioretention System

FEASIBILITY:

- Must be installed on slopes < 5%.
- Must not conflict with existing underground utility lines.
- Outlet pipe shall connect to existing stormwater conveyance system in the stream
- The maximum drainage area shall be 1 acre, unless sizing calculations will demonstrate that the system can handle a larger area.

CONVEYANCE:

- Conveyance to the system is by a field inlet structure that is an integral part of the treatment structure.

PRETREATMENT:

- Pretreatment is provided in the inlet structure of the modular wetland system.

SIZING CRITERIA:

- The Filterra Bioretention system may be sized for either the Water Quality Flow.
- Sizing calculators are available online at www.filterra.com for this purpose.

TREATMENT:

- The Filterra Bioretention system provides filtration, sedimentation and biological uptake to remove pollutants from stormwater.

CONSTRUCTION AND MAINTENANCE REQUIREMENTS:

- The Filterra Bioretention System must be installed in accordance with all the specifications provided by the manufacturer. (www.filterra.com).
- Inspection of Filterra and surrounding area shall be done twice a year.
- At time of inspection, remove tree grate and erosion control stones to access media surface.
- Remove trash, debris and mulch layer.
- Replace mulch on top of Bioretention media.
- Replace erosion control stones and clean area around Filterra.
- Complete written maintenance report and submit copy to municipal

Chapter 4
APPENDICES

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4.1 Definitions

Adverse Impact: Any deleterious effect on waters or wetlands, including their quality, quantity, surface area, species composition, aesthetics or usefulness for human or natural uses which are or may potentially be harmful or injurious to human health, welfare, safety or property, to biological productivity, diversity, or stability or which unreasonably interfere with the enjoyment of life or property, including outdoor recreation.

Bank full Discharge: Stream discharge that fills the channel to the top of the banks and just begins to spread onto the floodplain. Bank full discharges occur on average every 1 to 1.5 years in undisturbed watersheds and are primarily responsible for controlling the shape and form of natural channels.

Biological Oxygen Demand: A measurement of the oxygen demand of organic material which, when breaking down in water, consumes oxygen in the water column.

Bioretention: On-lot retention of storm water through the use of vegetated depressions engineered to collect, store, filter and infiltrate runoff.

Best Management Practice (BMP): The practice or combination of practices that are the most effective and practical means of reducing or eliminating the discharge of pollutants to surface waters from point or non-point source discharges, including storm water.

Buffer: A vegetated zone adjacent to a stream, wetland, or shoreline where development is restricted or controlled to minimize the effects of development.

Channel Protection Flow (CPf): Control the 2-yr, 24 hour post-development peak flow rate to 50 percent of the 2-yr, 24 hour pre-development level or to the 1-yr, 24 hour pre-development level.

Clear Cutting: The removal of all of the trees from a given land area.

Clearing: The removal of trees and brush from the land, but shall not include the ordinary mowing of grass.

Cluster (Open Space) Development: A development concept by which lots or buildings are concentrated in specific areas to preserve large, contiguous area of the natural environment while minimizing infrastructure and development costs. The preservation of large, contiguous areas of the natural environment allow for passive recreation, common open space, and preservation of environmentally sensitive features.

Conveyance Protection: Design the conveyance system leaching to, from, and through storm water management facilities based upon the 10-year, 24 hour storm event.

Curbs: Concrete or bituminous concrete barriers on the edge of streets used to direct storm water runoff to an inlet or storm drain and to protect lawns and sidewalks from vehicles.

Denitrification: Reduction of nitrate (commonly by bacteria) to nitrogen gas in an anaerobic environment.

Design Storm: A rainfall event of specific size, intensity, and return frequency that is used to calculate runoff volume and peak rate discharge.

Detention: The temporary storage of storm water to control discharge rates, allow for infiltration, and improve water quality.

Dry Detention Basin: A permanent structure for the temporary storage of runoff, which is designed so as not to create a permanent pool of water.

Dry Well: Hollow concrete or plastic structure, surrounded by crushed stone placed in the ground to control and infiltrate roof top runoff.

Easement: A grant or reservation by the owner of land for the use of such land by others for a specific purpose or purposes.

Erosion: The process of soil detachment and movement by forces of wind and water.

Environmental Site Design (ESD): The process of assessing and evaluating the natural resources on a site prior to the creation of development plans and the application of LID strategies to minimize the impact on the environment.

Evapotranspiration: Collective term for the processes of water returning to the atmosphere via interception and evaporation from plant surfaces and transpiration through plant leaves.

Exfiltration: Movement of water from an infiltration management practice into the surrounding soil layers.

Flow Attenuation: Prolonging the flow time of runoff to reduce the peak rate of discharge.

Grading: The act by which soil is cleared, stripped, stockpiled, excavated, scarified, and filled or any combination thereof.

Groundwater Recharge Volume (GRv): Maintain pre-development annual groundwater recharge volume to the maximum extent practicable through the use of infiltration measures.

Hydrologically Functional Landscape: Term used to describe a design approach for the built environment that attempts to more closely mimic the overland and subsurface flow, infiltration, storage, evapotranspiration, and time of concentration characteristic of the native landscape of the area.

Hydrologic Transparency: The use of LID design strategies and storm water treatment systems for a development scenario which yields hydrologic conditions matching or in extremely close proximity to the hydrologic conditions of the natural site prior to development.

Hydromodification: The alteration of a natural drainage system through a change in the system's flow characteristics.

Impervious Area: A hard surface that prevents or severely retards the entry of water into the soil, thus causing water to run off the surface in greater amounts and at an increased rate of flow when compared to natural conditions. The surfaces include, but are not limited to, conventional asphalt or concrete roads, parking areas, sidewalks, alleys and roof tops.

Infiltration: The downward movement of water from the land surface down into the soil.

Integrated Management Practices: The application of multiple storm water treatment systems to address increased runoff volumes from development. IMP offers several techniques including storm water harvest (to reduce the amount of water that can cause flooding), infiltration (to restore the natural recharge of groundwater), biofiltration or Bioretention (e.g., rain gardens) to store and treat runoff and release it at a controlled rate to reduce impact on streams and wetland treatments (to store and control runoff rates and provide habitat in urban areas).

Low Impact Development: The integration of site ecological and environmental goals and requirements into all phases of urban planning and design from the individual lot level to the entire watershed.

Nitrification: Process in which ammonium is converted to nitrite and then nitrate by specialized bacteria.

Non-point Source Pollutants: Pollutants in water caused by rainfall or snowmelt moving both over and through the ground and carrying with it a variety of pollutants associated with human land uses. A non-point source is any source of water pollution that does not meet the legal definition of point source in Section 502(14) of the Federal Clean Water Act.

NPDES: National Pollutant Discharge Elimination System is a regulatory program in the Federal Clean Water Act that prohibits the discharge of pollutants into the surface waters of the United States without a permit.

Open Space: Land set aside for public or private use within a development that is not built upon and is legally preserved in its natural state for perpetuity.

Phosphorous (P)-Index: The measure of the amount of phosphorous a soil contains. A low P-Index means a soil can absorb more phosphorous from the stormwater.

Peak Runoff Attenuation: Control the post-development peak discharge rates from the 10-yr, and 100-yr 24 hour storm events to the corresponding pre-development peak discharge rate, as required by the local regulatory authority.

Permeable: Soil or other material that allows for the infiltration or passage of water.

Recharge Zone: A land area in which surface water infiltrates the soil and reaches the zone of saturation or shallow groundwater table.

Retention Basin: A permanent structure that provides for the storage of runoff by means of a permanent pool of water.

Retrofitting: The construction of a BMP (both structural and non-structural) in a previously developed area, the modification of an existing BMP (both structural and non-structural), to improve the water quality over current conditions.

Runoff: Water from rain, snow melt or irrigation that flows over the land surface.

Runoff Curve Number (RCN): The runoff curve number is an empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall excess. The curve number method was developed by the USDA Natural Resources Conservation Service, which was formerly called the *Soil Conservation Service* or *SCS* — the number is still popularly known as a "SCS runoff curve number" in the literature. The runoff curve number was developed from an empirical analysis of runoff from small catchments and hillslope plots monitored by the USDA. It is widely used and is an efficient method for determining the approximate amount of direct runoff from a rainfall event in a particular area.

Sediment: Soils or other surfical materials transported or deposited by the action of wind, water, ice, or gravity as a product of erosion.

Site fingerprinting: The delineation of the smallest possible area for clearing and site disturbance where roads, structures and other improvements are to be constructed.

Stabilization: The prevention of soil movement by any of various vegetative and/or structural means.

Storm water Management Plan: A set of drawings or other documents submitted by a person(s) as a prerequisite to obtain a storm water management approval, which contains all of the information and specifications pertaining to storm water management and conforms to the standards found in the Design Manual.

Swale (generic): An open channel designed to convey storm water.

Time of Concentration: The time that it takes surface runoff to reach the outlet of a sub-basin or watershed from the most hydraulically distant point in that watershed.

<u>Vegetated Swale:</u> An open channel which is planted with grasses (primarily) convey runoff.

<u>Water Quality Volume (WQv):</u> The volume needed to capture and treat the runoff from the 90 percent of the average annual rainfall at a development site. Methods for calculating the water quality volume are specified in the Design Manual.

<u>Watercourse:</u> Any natural or artificial stream, river, creek, ditch, channel, canal, conduit, culvert, drain, waterway, gully, ravine, or wash in and including any adjacent area that is subject to inundation from overflow or flood water.

<u>Watershed:</u> The topographic boundary within which water drains to a particular stream, river, wetland or other body of water.

<u>Water Quality Flow (WCf):</u> Peak flow associated with the water quality volume calculated using the NRCS Graphical Peak Discharge Method.

<u>Water Quality Storm:</u> A rainfall event of 1.2” of rain in 24-hours which results in 1” of runoff from an impervious surface.

<u>Wet Swale:</u> A vegetated conveyance system also used to remove pollutants from storm water runoff.

4.2 Plant Lists for LID Treatment Systems

There are six distinct hydrological planting zones for Low Impact Development Treatment Systems. Table B defines the hydrological characteristics of each planting zone.

Table B – Hydrologic Planting Zones

Zone #	Hydrologic Condition	Zone Description
1	1-6 deep permanent pool	Deep Water Pool
2	6 inches to 1 foot deep	Shallow Water Bench
3	Regularly inundated	High & Low Marsh
4	Periodically inundated	Riparian Fringe, Aquatic Bench
5	Infrequently inundated	Upland terraces within pond/wetland system
6	Rarely inundated	Upland slopes

ZONE 1 – Deep Water Pool

Trees and shrubs: not recommended for this zone

Herbaceous Plants:

Coontail	Submergent
Duckweed	Submergent/Emergent
Pond Weed	Submergent
Waterweed	Submergent
Wild Celery	Submergent

ZONE 2 – Shallow Water Bench

Trees and shrubs:

Buttonbush	Deciduous shrub

Herbaceous Plants:

Arrow arum	Emergent
Arrowhead, Duck Potato	Emergent
Blue Flag Iris	Emergent
Blue Joint	Emergent
Broomsedge	Perimeter
Bushy Beardgrass	Emergent
Cattail	Emergent
Duckweed	Submergent/Emergent
Hardstem Bulrush	Emergent
Long-leaved Pond Weed	Rooted Submerged Aquatic
Pickerelweed	Emergent
Sedges	Emergent
Soft-stem Bulrush	Emergent

Smartweed	Emergent
Herbaceous Plants:	
Soft Rush	Emergent
Switchgrass	Perimeter
Sweet Flag	Herbaceous
Wild Rice	Emergent
Wool Grass	Emergent

ZONE 3 – High & Low Marsh

Trees and shrubs:

Arrowwood Viburrium	Deciduous shrub
Bald Cypress	Deciduous tree
Black Ash	Deciduous tree
Black Willow	Deciduous tree
Buttonbush	Deciduous shrub
Elderberry	Deciduous shrub
Larch	Coniferous tree
Pin Oak	Deciduous tree
Red Maple	Deciduous tree
River Birch	Deciduous tree
Silky Dogwood	Deciduous tree
Smooth Alder	Deciduous tree
Swamp White Oak	Deciduous tree
Winterberry	Deciduous shrub

Herbaceous Plants:

Arrow arum	Emergent
Arrowhead, Duck Potato	Emergent
Blue Flag Iris	Emergent
Blue Joint	Emergent
Broomsedge	Perimeter
Bushy Beardgrass	Emergent
Cattail	Emergent
Duckweed	Submergent/Emergent
Flat-top Aster	Emergent
Hardstem Bulrush	Emergent
Long-leaved Pond Weed	Rooted Submerged Aquatic
Pickerelweed	Emergent
Redtop	Perimeter
Sedges	Emergent
Soft-stem Bulrush	Emergent
Smartweed	Emergent
Soft Rush	Emergent
Switchgrass	Perimeter

Sweet Flag	Herbaceous
Herbaceous Plants:	
Wild Rice	Emergent
Wool Grass	Emergent

ZONE 4 – Riparian Fringe, Aquatic Bench

Trees and shrubs:

American Elm	Deciduous tree
Arrowwood Viburrium	Deciduous shrub
Bald Cypress	Deciduous tree
Black Ash	Deciduous tree
Black Gum	Deciduous tree
Black Willow	Deciduous tree
Buttonbush	Deciduous shrub
Eastern Cottonwood	Deciduous tree
Elderberry	Deciduous shrub
Larch	Coniferous tree
Pin Oak	Deciduous tree
Red Maple	Deciduous tree
River Birch	Deciduous tree
Shadowbush	Deciduous shrub
Silky Dogwood	Deciduous tree
Slippery Elm	Deciduous tree
Smooth Alder	Deciduous tree
Swamp White Oak	Deciduous tree
Sweetgum	Deciduous tree
Winterberry	Deciduous shrub
Witch Hazel	Deciduous shrub

Herbaceous Plants:

Big Bluestem	Perimeter
Birdfoot deervetch	Perimeter
Blue Joint	Emergent
Broomsedge	Perimeter
Cardinal Flower	Perimeter
Fowl Bluegrass	Emergent
Green Bulrush	Emergent
Redtop	Perimeter
Tufted Hairgrass	Perimeter
Smartweed	Emergent
Soft Rush	Emergent
Swamp Aster	Emergent
Water Plantain	Emergent

ZONE 5 – Upland Terraces within Pond / Wetland Systems

Trees and shrubs:

American Elm	Deciduous tree
Bayberry	Deciduous shrub
Black Ash	Deciduous tree
Black Cherry	Deciduous tree
Black Gum	Deciduous tree
Black Willow	Deciduous tree
Buttonbush	Deciduous shrub
Eastern Cottonwood	Deciduous tree
Eastern Hemlock	Coniferous tree
Elderberry	Deciduous shrub
Green ash	Deciduous tree
Pin Oak	Deciduous tree
Red Maple	Deciduous tree
River Birch	Deciduous tree
Shadowbush	Deciduous shrub
Silky Dogwood	Deciduous tree
Slippery Elm	Deciduous tree
Smooth Alder	Deciduous tree
Swamp White Oak	Deciduous tree
Sweetgum	Deciduous tree
Winterberry	Deciduous shrub
Witch Hazel	Deciduous shrub

Herbaceous Plants:

Annual Ryegrass	Perimeter
Big Bluestem	Perimeter
Cardinal Flower	Perimeter
Creeping Red Fescue	Perimeter
Redtop	Perimeter
Switchgrass	Perimeter

ZONE 6 – Upland Slopes

Trees and shrubs:

American Elm	Deciduous tree
Bayberry	Deciduous shrub
Black Cherry	Deciduous tree
Eastern Hemlock	Coniferous tree
Eastern Red Cedar	Coniferous tree
Elderberry	Deciduous shrub
Pin Oak	Deciduous tree
Red Maple	Deciduous tree

Shadowbush	Deciduous shrub
Trees and shrubs:	
Sweetgum	Deciduous tree
White Ash	Deciduous tree

Herbaceous Plants:

Birdfoot deervetch	Perimeter
Cardinal Flower	Perimeter
Switchgrass	Perimeter

4.3 Stormwater Management Checklist

A.1 General Information

- ☐ Applicant's name, mailing address, telephone number, email
- ☐ Name, address, phone and email of licensed professional engineer responsible for the preparation of the stormwater management plan
- ☐ Street address of project site
- ☐ Vicinity map at a scale of 1" = 1000' or larger
- ☐ Current zoning and land use
- ☐ Proposed use of property

A.2 Mapping Requirements for Existing Natural Resources

- ☐ Overall plan at a scale not to exceed 1" = 100'
- ☐ North arrow
- ☐ Existing topography (2' contours based upon aerial or field mapping)
- ☐ Location of all man-made features on or adjacent to the site, such as roads, drainage systems, utilities, and buildings
- ☐ Location of inland wetlands and watercourses as defined by Certified Soil Scientist in the field and flags located by a licensed land surveyor
- ☐ Location of vernal pools, swamps, or bogs by qualified environmental consultant
- ☐ Location of floodway for 100-year storm event, the 100-year flood plain, the 500-year flood plain, if applicable from current FEMA mapping
- ☐ Mapping of upland soil types by either soil scientist or NRCS mapping
- ☐ Extent and type of different vegetative communities on the site
- ☐ Location of stone wall and/or farm hedgerows
- ☐ Delineation of existing watershed boundaries on the site
- ☐ Delineation of 20% slopes on the site

A.3 Mapping Requirements for Proposed Project

- ☐ Location & results of soil test pits performed on the site

- ☐ Delineation of proposed watershed boundaries on the site
- ☐ Location of proposed roads, lot lines, buildings, driveways and other improvements to the site
- ☐ Location of all proposed stormwater management conveyance and LID treatment systems

A.4 Compliance with Tab 2.0 – Performance Requirements

A. Groundwater Recharge Volume

- ☐ Provide amount and type of impervious cover in each subwatershed area
- ☐ Provide calculations of Groundwater Recharge Volume for each post-development subwatershed area and for each soil type within the area
- ☐ Provide the amount of volume required to meet the Groundwater Recharge Volume

B. Water Quality Volume

- ☐ Provide amount and type of impervious cover in each subwatershed area
- ☐ Provide calculations for the Water Quality Volume for each subwatershed area
- ☐ Provide the amount of volume required to meet the Water Quality Volume

C. Pollutant Renovation Analysis

- ☐ Provide pollutant loading analysis to demonstrate that all Water Quality Goals will be achieved by the proposed stormwater treatment systems

D. Channel Protection Flow

- ☐ Calculate the Channel Protection Flow for each discharge point of the stormwater management system as applicable
- ☐ Demonstrate how the reductions in peak rate for the 2-year post-development storm will be reduced to comply with this requirement
- ☐ Provide time of concentration calculations for each area for pre- and post-development conditions
- ☐ Provide Runoff Curve Numbers for each area for pre- and post-development conditions
- ☐ Provide routing analyses for stormwater management system being used to meet this requirement

E Flood Protection

- ☐ Calculate the peak rate of runoff for the 10-year, 24-hour storm event and the 100-year, 24-hour storm event, if necessary for each watershed area as applicable
- ☐ Provide time of concentration calculations for each area for pre- and post-development conditions
- ☐ Provide Runoff Curve Numbers for each area for pre- and post-development conditions
- ☐ Provide routing analyses for stormwater management system being used to meet this requirement

F. Water Quality Flow

- ☐ Calculation of the water quality flow for off-line treatment systems

4.4 Preparing an Environmentally-Friendly Site Design

A. Obtain a topographic base map of the property which will provide existing contours at a 2' interval,
B. Obtain field delineation by an appropriate professional of Primary Conservation Areas and Secondary Conservation Areas as identified in Section 3.16 of the Subdivision Regulations,
C. Create a base map identifying Primary Conservation Areas and Secondary Conservation Areas,
D. Identify the preliminary developable area on the parcel by removing the Primary Conservation Areas and Secondary Conservation Areas,
E. Prepare plans for development of the site utilizing the following guidelines:

I. Avoidance of Impacts:

a. Protect as much undisturbed land as possible to maintain pre-development hydrology through interception of rainfall by vegetation, evaportranspiration, and infiltration.
b. Protect the natural drainage systems, such as wetlands, watercourses, ponds, vernal pools, and natural depressions on the landscape to the maximum extent possible. These areas can collect, hold and in the case of natural depressions infiltrate rainfall into the ground,
c. Minimize the extent of land clearing and the disturbance and/or grading of natural soils. Undisturbed soils have significantly higher infiltration rates than disturbed soils
d. Preserve those soils with high to moderate infiltration rates (Soil Classes A and B) by concentrating impervious surfaces on those soils with low infiltrative capacities (Soil Class C),
e. Implement techniques to prevent the compaction of natural soils.

II. Reduction of Impacts:

a. Minimize the extent of and connectiveness impervious areas on the site,
b. Increase the “Time of Concentration” for post-development conditions to closely approximate or match the “Time of Concentration” for pre-development conditions by the utilization of overland flow across naturally vegetated surfaces to the maximum extent practical,
c. Utilize low maintenance landscapes that will encourage the retention and planting of native types of vegetation, and minimize the extent of lawn areas.

III. Management of Impacts:

a. Use vegetated conveyance and source treatment systems to collect and infiltrate runoff as close as possible to the source of the runoff, such as Bioretention systems for roof drains,
b. Use rain barrels or cisterns to collect and reuse runoff from roof areas for non-potable purposes,
c. Disconnect impervious areas to the maximum extent practical by directing runoff from impervious surfaces onto vegetated surfaces,
d. Utilize deep soil scarification (a minimum of 12” below finish grade) on disturbed soils to loosen the soils and increase the infiltrative capacity of the soils,

e. Implement procedures to prevent or minimize the use of compounds which are responsible for the pollutants found in non-point source runoff. This includes reducing the use of sand and salt on roads, parking areas and driveways without compromising the safety of these surfaces,
f. Reduce the use of fertilizers and pesticides on lawn and landscape area to the maximum extent practical,
g. Utilize multiple stormwater treatment systems in series to reduce pollutant loads from stormwater as well as infiltrate runoff prior to discharging to natural wetland or watercourse systems.

F. Utilize the following guidelines for site layout:

I. **Road Layout and Design:**

a. Road alignments shall follow the existing contours to the maximum extent practical to minimize excessive cuts and fills,
b. Minimize the extent of directly connected impervious area to the maximum extent practical. This can be achieved by the minimization of drainage structures on the road, such as catch basins and connecting pipe and the use of vegetated swales along the road in appropriate locations,
c. Utilize LID treatment strategies to treat runoff at the source and not at the end of the pipe,
d. Utilize multiple LID treatment systems in a series to increase the effectiveness of the pollutant removal from the stormwater.

II. **Driveway Layouts:**

a. Layout out the location of the driveway to minimize cuts and fills,
b. Use impervious area disconnection strategies to intercept, and direct runoff to vegetated surface or vegetated treatment system prior to the runoff reaching the road,
c. Direct runoff from driveway onto vegetated areas for a minimum of 75’ to facilitate infiltration.

III. **Lot Designs:**

a. Layout lots in such a manner as to minimize site clearing by delineating the smallest possible area for clearing and site disturbance where roads, structures and other improvements are to be constructed,
b. Layout buildings, driveway and on-site sewage disposal systems in such a manner as to minimize the extent of soil disturbance and grading on the lot,
c. Utilize the natural topography when siting a proposed building to minimize site disturbance (such as creating a walkout basement for a building on a natural 15-20% slope),
d. Avoid randomly disturbing areas of the site where it is not necessary, this will preserve the infiltrative capacity of native soils,

e. Use “source” controls such as rain barrels for roof runoff to collect and reuse runoff; rain gardens for roof runoff to infiltrate runoff into the ground; impervious area disconnection to allow runoff to occur as overland flow across a vegetated surface,
f. Consider the use of meadow filter strips at the downhill limits of development to filter runoff prior to leaving the lot.

4.5 Maintenance Agreement for Stormwater Systems

Note: Stormwater Maintenance Agreement "A" was reproduced from the New York State Stormwater Manual.
Note: Stormwater Maintenance Agreement "B" was reproduced from the Town of Southbury, CT and is for Bioretention systems only.

Stormwater Maintenance Agreement "A"

Whereas, the Municipality of East Granby ("Municipality") and the ______________________________ ("facility owner") want to enter into an agreement to provide for the long term maintenance and continuation of stormwater control/treatment measures approved by the Municipality for the below named project, and

Whereas, the Municipality and the facility owner desire that the stormwater control/treatment measures be built in accordance with the approved project plans and thereafter be maintained, cleaned, repaired, replaced, and continued in perpetuity in order to ensure optimum performance of the stormwater systems. Therefore, the Municipality and the facility owner agree as follows:

1. This agreement binds the Municipality and the facility owner, its successors and assigns, to the maintenance provisions depicted in the approved project plans which are attached as Schedule A of this agreement.

2. The facility owner shall maintain, clean, repair, replace and continue the stormwater control/treatment measures depicted in Schedule A as necessary to ensure optimum performance of the measures to design specifications. The stormwater control/treatment measures shall include, but shall not be limited to, the following: catch basins, mechanical treatment systems, Bioretention facilities, swales, sand or organic filters, infiltration systems, permeable pavement systems, subsurface gravel wetlands, constructed wetlands and ponds.

3. The facility owner shall be responsible for all expenses related to the maintenance of the stormwater control/treatment measures and shall establish a means for the collection and distribution of expenses among parties for any commonly owned facilities.

4. The facility owner shall provide for periodic inspection of the stormwater control/treatment measures on an annual basis, to determine the condition and integrity of the measures. Such inspection shall be performed by a Professional Engineer licensed by the State of Connecticut. The inspecting engineer shall prepare and submit to the Municipality within 30 days of the inspection, a written report of the findings including recommendations for those actions necessary for the continuation of the stormwater control/treatment measures.

5. The facility owner shall not authorize, undertake or permit alteration, abandonment, modification or discontinuation of the stormwater control/treatment measures except in accordance with written approval of the Municipality.

6. The facility owner shall undertake necessary repairs and replacement of the stormwater control/treatment measures at the direction of the Municipality or in accordance with the recommendation of the inspecting engineer.

7. The facility owner shall provide to the Municipality within 30 days of the date of this agreement, a security for the maintenance and continuation of the stormwater control/treatment measures in the form of (a Bond, letter of credit or escrow account).

8. This agreement shall be recorded in the Town Clerks Office, Town of East Granby together with Schedule A.

9. If ever the Municipality determines that the facility owner has failed to construct or maintain the stormwater control/treatment measures in accordance with the project plan or has failed to undertake corrective action specified by the Municipality or by the inspecting engineer, the Municipality is authorized to undertake such steps as reasonably necessary for the preservation, continuation, or maintenance of the stormwater control/treatment measures and affix the expenses thereof as a lien against the property.

10. This agreement is effective ______________________.

Effective Date: 2/4/12

Stormwater Maintenance Agreement "B"

Notice of Ongoing Maintenance Obligation
(Name of Subdivision or Property)
(Applicable Lot Numbers)
BIORETENTION MAINTENANCE

KNOW ALL MEN BY THESE PRESENTS:

That ***(name of the legal owner of record)*** with an address of ***(legal address of owner of record)*** pursuant to the approval of the Inland Wetlands & Watercourses Commission and/or the Planning & Zoning Commission of ***(name of project)***, located on ***(street name)*** in East Granby files this Notice of On-going Maintenance Obligation (the "Notice") in order to set forth the required maintenance for the Bio-retention systems located on lots (numbers of affected lots in development or other reference) of the subdivision (the "Affected Lots"). The Affected lots are described at Schedule A, attached hereto and made a part hereof.

Pursuant to the Approval, the ***(name of legal owner of record)*** files this Notice to give constructive notice to all potential purchasers of approved lots within the Subdivision, of the Town of East Granby's Inland Wetland & Watercourse Commission's and/or Planning & Zoning Commission conditions of approval requiring the ***(name of legal owner of record)*** to propose a maintenance plan for all Bioretention systems. The maintenance plan for the Bioretention systems is attached at Schedule B, attached hereto and made a part hereof.

Upon receipt of this Notice any potential purchaser of one of the lots indicated above should direct any questions about the maintenance plan and rain garden purpose or function to the East Granby Land Use Office.

IN WITNESS WHEREOF, (name of legal owner of record), duly authorized, has hereunto set his hand and seal this ____ day of _________ 2010, as his free act and deed.

____

________________________________ ________________________________

(name of legal owner of record), duly authorized

STATE OF CONNECTICUT)
) ss: East Granby ***(month)*** _____, ***(year)***
COUNTY OF EAST GRANBY)

On this the _____ day of _______________, ***(year)***, before me, the undersigned officer, personally appeared (name of legal owner of record) of the State of Connecticut, known to me (or satisfactorily proven) to be the person described in the foregoing instrument, and acknowledged that he, duly authorized, executed the same as his free act and deed in the capacity therein stated and for the purposes therein contained.

In witness whereof I hereunto set my hand.

____

Commissioner of the Superior Court
Notary Public
My commission expires:

SCHEDULE A

LEGAL DESCRIPTION OF AFFECTED LOTS

All those certain pieces or parcels of land designated as ***(Listing of Lot numbers)*** all as shown on a certain map entitled (Name of subdivision Map, Name of Applicant, Street location of property, Map date, Map scale, sheet numbers, if applicable, revision dates as applicable) certified by (Name and license number of land surveyor, license number and Firm Name, if applicable) ", which Map is filed in the East Granby Town Clerk's office in Map Book Volume _____ at Pages _____.

SCHEDULE B

MAINTENANCE PLAN FOR BIORETENTION SYSTEMS

Soil:

Visually inspect soil surface in the month of May and October.

If water appears to be ponding for more than 24 hours, use small claw rake and loosen soil surface in the Bioretention system.

Do not use any mechanical equipment in the Bioretention system as this will compact the soils.

Mulch:

Inspect mulch around plant stems in the Spring

Re-mulch around plant stems only as needed.

Plants:

Immediately after the completion of rain garden construction, water plant material for 14 consecutive days unless there is sufficient natural rainfall.

When trees have taken root, or at least by 6 months, remove stakes and wires.

Once a month during the spring and summer visually inspect vegetation for disease or pest problems.

Twice a year, once between April 15 to May 30 and once between October 1 to November 30, remove and replace all dead and diseased vegetation considered beyond treatment.

Remove accumulated leaves from the Bioretention system in the fall.

During times of extended drought, look for physical features of stress (wilting, yellow, spotted or brown leaves, loss of leaves, etc). Water in the early morning as needed.

Weed as needed. Prune excess growth annually. Remove dead organic matter from the facility.

General:

After large rain events, inspect the rain garden and make sure that drainage paths are clear and that ponded water dissipates over 24-48 hours. It should not provide a breeding ground for mosquitoes. Water must remain stagnant for at least 72 hours after a rainfall event for mosquito larvae to develop.

Professional Resources:

If the Bioretention system has been designed and constructed in accordance with the specifications and standards found in the Town of East Granby Low Impact Development and Stormwater Management Design Manual, it will function appropriately. If the Bioretention system is not functioning properly, the owner should contact the design professional who designed the Bioretention system for assistance in restoring the functionality of the facility.

4.6 LID References

A. Analysis of Treatment System Performance, International Stormwater Best Management Practices Database, June 2008 by EWRI/ASCE

B. 2004 Connecticut Stormwater Quality Manual, CT Department of Environmental Protection

C. Environmental Site Design Supplement, Maryland Stormwater Design Manual, Maryland Department of the Environment, 2009

D. Innovative Land Use Planning Techniques – A Handbook for Sustainable Development; NH Department of Environmental Services, October 2008

E. Low-Impact Development Design Strategies, An integrated Design Approach; Prince George's County, Maryland, Programs and Planning Division of the Department of Environmental Resource, June 1999

F. Low-Impact Development Hydrologic Analysis; Prince George's County, Maryland, Programs and Planning Division of the Department of Environmental Resource, July 1999

G. Low Impact Development – Technical Guidance Manual for Puget Sound, January 2005; Puget Sound Action Team – Washington State University Pierce County Extension

H. Natural Approaches to Stormwater Management – Low Impact Development in Puget Sound, March 2003; Puget Sound Action Team

I. Maryland Stormwater Design Manual, Maryland Department of the Environment, 2000

J. National Pollutant Removal Database, 2nd Edition; March 2000; Center for Watershed Protection

K. National Pollutant Removal Database, Version 3.0, Center for Watershed Protection, September 2007

L. National Stormwater Quality Database, Version 1.1 – A compilation and Analysis of NPDES Stormwater Monitoring Information; Alex Maestre and Robert Pitt, Department of Civil Engineering, University of Alabama, Center for Watershed Protection, September 4, 2005

M. New Hampshire Stormwater Manual, Volume 1 – Stormwater and Antidegradation, NH Department of Environmental Services, December 2008

N. Protecting Water Resources and Managing Stormwater – A Bird's Eye View for New Hampshire Communities; Julia Peterson (NH Sea Grant and UNH Cooperative Extension), Amanda Stone (UNH Cooperative Extension), James Houle (UNH Stormwater Center)

O. Rhode Island Stormwater Design and Installation Standards Manual and Appendices, August 2010

P. The Practice of Watershed Protection, Center for Watershed Protection, 2000

Q. The Sustainable Sites Initiative – Guidelines and Performance Benchmarks, 2009. American Society of Landscape Architects

R. The Sustainable Sites Initiative – The Case for Sustainable Landscapes, 2009. American Society of Landscape Architects

S. Town of East Granby – Design Manual: Low Impact Development, Stormwater Management Systems, Performance Requirements, Road Design and Stormwater Management, February 1, 2008

T. University or New Hampshire Storm Water Center, 2007 and 2009 Annual Reports

U. UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds, October 2009. University of New Hampshire, Cooperative Institute for Coastal and Estuarine Environmental Technology, Durham, NH

V. UNHSC Subsurface Gravel Wetland Design Specifications, June 2009. University of New Hampshire, Cooperative Institute for Coastal and Estuarine Environmental Technology, Durham, NH

Low Impact Development Website Links:

A. Low Impact Development Center http://www.lowimpactdevelopment.org/

B. University of New Hampshire Stormwater Center http://www.unh.edu/erg/cstev/

C. Wisconsin Department of Natural Resources http://dnr.wi.gov/

D. Low Impact Development (LID) Urban Design Tools http://www.lid-stormwater.net/index.html

E. The Sustainable Site Initiative http://www.sustainablesites.org/

F. Environmental Protection Agency http://www.epa.gov/nps/lid/

G. Puget Sound Action Team http://www.psp.wa.gov/

H. Center for Watershed Protection http://www.cwp.org/

I. North Carolina State University Stormwater Engineering Group

http://www.bae.ncsu.edu/stormwater/

Chesapeake Stormwater Network http://www.chesapeakestormwater.net