DESIGN SPECIFICATION

2.7 Rain Garden Bioretention System

filtrexx® SUSTAINABLE TECHNOLOGIES

PURPOSE & DESCRIPTION

The Filtrexx® **Rain Garden Bioretention System** is a storm water best management practice (BMP) that u**tilizes soil, plants, and microbes to filter, retain, and infiltrate storm water runoff from developed sites.** Rain gardens are an important component of Low Impact Development (LID) strategies because it is relatively simple, inexpensive, effective and aesthetically attractive. Filtrexx® GrowingMedia™ is an important component of a successful rain garden installation.

APPLICATION

Rain gardens can be used on virtually any site utilizing a variety of design techniques. The most straightforward designs are on sites that (Winogradoff, 2001):

- Allow the rain garden facility to be located in close proximity to the source of run-off.
- Allow rain garden facilities to be dispersed uniformly throughout the site.
- Allow each rain garden facility to collect runoff from a sub-drainage area of one acre or less (maximum of two acres).
- Are large enough to accommodate the rain garden facilities within required setbacks.
- Contain high infiltration, stabile, and well structured in-situ soils.

Rain gardens can be installed on sites that do not meet all of these criteria, but it can be more difficult and often less successful. The key components of a rain garden are (Winogradoff, 2001):

- Pretreatment – it is important to filter excess debris and sediment from runoff before it reaches the rain garden in order to minimize maintenance.
- Flow Entrance – It is best to allow water to sheet flow directly into the facility, where concentrated flows enter through a curb cut or pipe it is important to dissipate the velocity of the runoff with stone, rip rap, or similar method.
- Ponding Area – The surface storage of runoff is accommodated in the ponding area. Acceptable depths range from 3 in -12 in (75-300mm), with 6 in (150mm) recommended.
- Plant Materials – Plants in a rain garden facility help to bind and uptake pollutants, remove water through evapotranspiration, encourage infiltration, and create an aesthetically pleasing landscape feature.
- Mulch – The mulch layer is an important medium for the adsorption and filtering of pollutants, as well as protecting the soil from eroding and drying out. A 3 in (75mm) blanket of Filtrexx® FilterMedia™ is recommended for this application.
- Planting Soil – The soil in a rain garden facility is specifically designed to filter pollutants, infiltrate water, and support plant growth. The soil must have a minimum infiltration rate of 2 in (50mm)/hr. A mixture of 75% coarse construction sand (grain size 0.02 in – 0.04 in [0.5-1.0mm]) and 25% GrowingMedia is recommended for this application.
- Underdrain with Pea Gravel Diaphragm – An underdrain is necessary when in-situ soils have an infiltration rate of less than 1 in/hr in order to ensure that the facility drains properly. A perforated pipe surrounded with a 6-9 in (150-225mm) layerof pea gravel that leads to a discharge point will serve this purpose.
- Overflow Outlet – All rain garden facilities must provide a means for excess water to overflow and be conveyed downstream.

ADVANTAGES AND DISADVANTAGES

Advantages

(Winogradoff, 2001; Hunt and Lord, 2006)

- Rain gardens reduce the volume of stormwater runoff leaving a developed site through interception of rainfall on vegetated surfaces.
- Rain gardens reduce the volume of stormwater runoff leaving a developed site through infiltration of runoff into the soil and groundwater.
- Rain gardens reduce the volume of stormwater runoff leaving a developed site through evapotranspiration.
- Rain gardens filter pollutants commonly found in storm water runoff by facilitating the settling of large particles.
- Rain gardens filter pollutants commonly found in storm water runoff by filtration through vegetation, GrowingMedia, and soil.
- Rain gardens filter pollutants commonly found in storm water runoff by uptake and assimilation by vegetation.
- Rain gardens filter pollutants commonly found in storm water runoff by adsorption to surfaces of solids in the soil mix and humus in GrowingMedia.
- Rain gardens filter pollutants commonly found in storm water runoff by decomposition of organic compounds by soil bacteria, fungi, and macro fauna.
- Rain gardens can reduce the temperature of storm water runoff before it enters surface water bodies.
- Rain gardens provide attractive landscape opportunities, which have been shown to increase property values up to 20%.
- Rain gardens create wildlife habitat and a sense of place when plants native to the region are specified.
- Rain gardens can increase awareness and stewardship of the environment.
- Rain gardens are a permanent BMP that will provide years of benefit.
- Rain gardens are adaptable, and designs can be customized to accommodate virtually any site.
- Proper rain garden design can help developed sites mimic pre-development hydrology.
- Rain gardens are an important component of a LID approach to storm water management.
- Rain gardens can often be retrofitted into existing sites.
- If planned appropriately, the comprehensive use of rain gardens,

ADVANTAGES			
	LOW	MED	HIGH
Installation Difficulty	✓		
Sediment Control		✓	
Solluable Pollutant Control			✓
Infiltration Reduction		✓	
Runoff Velocity Reduction		✓	
Vegetation Establishment			✓

rather than conventional pipe and pond methods, can save 15-50% of site development costs.
- Rain gardens may assist in qualification for LEED® Green Building Rating and Certification credits under LEED Building Design & Construction (BD+C), New Construction v4. Awarded credits may be possible from the categories of Sustainable Sites, Water Efficiency, Materials & Resources, and Innovation. *Note: LEED is an independent program offered through the U.S. Green Building Council. LEED credits are determined on a per project basis by an independent auditing committee. Filtrexx neither guarantees nor assures LEED credits from the use of its products. LEED is a trademark of the U.S. Green Building Council.*

Disadvantages
- If not installed correctly, maintained or used for a purpose or intention that does not meet specifications, performance may be diminished.
- If rain garden soil is not the specified mix of sand and GrowingMedia, performance may be diminished.
- If rain garden soils are compacted, performance may be severely diminished.
- Rain gardens should not be used in areas with a high water table (must be 2 in (50mm) below the invert elevation of the facility.
- Each rain garden facility should not receive runoff from a drainage area of greater than 1 acre (0.4 ha) with max 2 acres (0.8 ha).
- Rain garden facilities should not receive concentrated, high-velocity flows.
- Rain garden facilities should be located 100 ft (30m) or more away from wells or source-water locations.
- Rain garden facilities should be placed 50 ft (15m) or more away from the edge of septic drain fields.
- Rain garden facilities should be placed 5 ft (1.5m) or more away from buildings and foundations, and at least 25 ft (8m) away from basements. If bedrock or subsurface geologic formations direct subsurface flow toward building foundation, distances should be increased.

MATERIAL CHARACTERISTICS

Rain gardens use only Filtrexx photodegradable or biodegradable netting materials available from Filtrexx International, and are the only mesh materials accepted in creating filtration systems for any application. For SiltSoxx Material Specifications see Table 7.1.

GROWINGMEDIA™ CHARACTERISTICS

Rain garden designs use only Filtrexx GrowingMedia which is a composted material that is specifically designed for management of storm water runoff, and establishment and sustainability of plant vegetation. GrowingMedia may be third party tested to meet minimum performance criteria defined by Filtrexx International. Performance parameters include: hydraulic flow-though rate, percent cover of vegetation, water holding capacity, pH, organic matter, soluble salts, moisture content, biological stability, percent inert material, bulk density and particle size distribution. For information on the physical, chemical, and biological properties of GrowingMedia refer to refer to Specification 6.2 Filtrexx® GrowingMedia™.

PERFORMANCE

Testing conducted at the Soil Control Lab, Inc. under simulated runoff conditions of sediment-laden water found that hydraulic flow-through rates for GrowingMedia used in Runoff diversion is less than 1 gpm/linear ft (<1 L/min/m). Field testing conducted by Filtrexx International has shown that vegetation establishment can be near 100%. Although research has not been conducted on Filtrexx rain gardens, conservative assumptions can be made from performance testing and research on Filtrexx® Compost Erosion Control Blanket™ and Filtrexx SiltSoxx®. Summaries of performance testing and research results from these systems can be found in the Appendices. Hunt and Lord (2006) reported that rain gardens can:

- Reduce Nitrogen loads up to 40%,
- Reduce TSS up to 98%,
- Reduce metals up to 95%,
- Reduce COD up to 97%,
- Reduce Temperatures 5-10 degrees, and
- Reduce oil and grease 67%.

Dietz and Clausen (2006) reported that a 2 in (50 mm) layer of organic hardwood mulch on the surface of a rain garden retained 33% of total total nitrogen (TN) and 100% of total total phosphorus (TP) inputs from storm runoff over a 2 yr period. Further, the organic layer retained 98%, 36%, and 16% of copper (Cu), lead (Pb), and zinc (Zn) inputs, respectively. The study concluded that the organic layer was a sink for nutrient and metal pollutants, retaining a much greater percentage of these pollutants than the vegetation in the rain garden. *Note: The Engineer may work outside the minimum construction requirements as needed to create a functioning stormwater management system.*

DESIGN CRITERIA

Sizing

There are many methods available to size rain garden areas. Check with your local development office or jurisdictional storm water management design manual to determine if there are specific guidelines or requirements for your area. A simple method is provided here.

Step 1: Delineate the development site drainage in the pre and post development condition. Delineate sub drainage divides for the post development condition, identifying strategic locations for possible rain garden facilities. rain gardens are most effective with many small facilities distributed throughout the site. The drainage area for each facility should be one acre or less, with a maximum of two acres.

Step 2: Determine the 'first flush' rainfall amount in your area. This should be somewhere between a 0.5 in (15mm) and 1.5 in (40mm) rainfall event. If no information exists for your area, use 1 in as the first flush event.

Step 3: Determine the amount of runoff contributed by each sub drainage area during the first flush rain event. This can be done in two steps, starting by using an equation from the National Resource Conservation Service (NRCS), TR-55 Method, to determine the amount of runoff from a given surface:

$$\text{Runoff depth (in,mm)} = (P - 0.2\,S)^2 \div (P + 0.8\,S)$$

Where,
P = Precipitation (typically use 1 in [25mm])
S = 1,000 ÷ CN – 10
CN = Curve Number

CN is a measure of the amount of water that will infiltrate a particular surface type during a storm. Curve Numbers for various surface types are provided by the NRCS, and some are summarized in Table 7.2.

Step 4: Determine a volume of water to be collected in the rain garden facility. Multiply the Runoff Depth from above (upslope) by the area of the sub drainage area. Be sure to convert the runoff depth from inches to feet before continuing.

Runoff Volume (cubic ft., cubic m) = Drainage Area x Runoff Depth

This is the total volume that the rain garden must hold for this sub drainage area.

Step 5: Determine the surface area required for the rain garden facility. Simply divide the volume by the design depth (typically 0.5 ft [150mm])

Rain garden Surface Area = Rain garden Volume ÷ Rain garden Depth

Gradient:
The bottom of the rain garden facility should be level and flat in order to disperse the inflow across the entire surface area and prevent concentration in low areas.

Rain gardens should not be placed in areas that have slopes greater than 20%.

Overflow
Since rain gardens are designed to collect runoff from relatively small and frequent storm events, an alternate path must be provided for runoff during large (anything larger than the first flush rainfall amount) storm events. The overflow can be accommodated over the top of the rain garden area if the top and the conveyance channel downstream are appropriately stabilized. More typically, an overflow pipe is provided in the rain garden facility with the top of the pipe set at the design depth of the rain garden facility. The downstream discharge point must be appropriately stabilized.

Soil Depth
For the best pollutant removal performance, the rain garden soil depth should be at least 30 in (750mm). The rain garden should be installed on non-compacted soil with a minimum of 2 ft (600mm) between the bottom of the structure and bedrock. Areas underlain by carbonate geology may require an impermeable lining based on municipal ordinances or at the recommendation of a geologic site investigation.

Existing Vegetation
Existing trees or other native vegetation should not be cleared to make room for rain garden. Plan ahead to save areas of existing vegetation and locate rain garden in disturbed areas.

INSTALLATION

1. GrowingMedia used for rain garden facilities shall meet all Filtrexx Certified GrowingMedia specifications.
2. Call Filtrexx at 877-542-7699 or visit www.filtrexx.com for a current list of installers and distributors of Filtrexx products.
3. Schedule a pre-construction meeting with Engineer, Filtrexx Certified Installer, and any other consultants that will be involved in the rain garden installation.
4. Rain garden facilities will be placed at locations indicated on plans as directed by the Engineer.
5. Rain garden areas should be protected from compaction during the site construction phase.
6. Construction site shall be graded and stabilized prior to the installation of rain garden facilities.
7. If in-situ soils were compacted during site construction, they shall be roto-tilled to a depth of 18 in (450mm) to restore porosity and infiltration capacity in areas designated for rain gardens.
8. Excavation and grading of rain garden areas shall be done by equipment located outside of the limits of the rain garden facility, or by equipment with marsh tracks or light equipment with turf-type tires.
9. Rain garden areas must be protected from erosion and sedimentation after final grades have been established for the facility.
10. Install underdrain system and observation wells, if specified.
11. Rain garden soil mix shall consist of 25% GrowingMedia and 75% coarse (grain size 0.02 in – 0.04 in [0.5-1.0mm]) construction sand that is clean and free of deleterious materials. The soil shall be mixed thoroughly to ensure a homogonous and consistent texture.
12. Rain garden soils shall be installed in lifts of 12 – 18 in (300-450mm) pneumatically or with non compacting methods. Each lift shall be lightly watered to encourage natural compaction. No mechanical compaction is permitted.
13. Rain garden's base should be at least 2 ft (600mm) above bedrock or geologic structures.
14. Rain garden soil mix shall have a minimum infiltration rate of 2 in (50mm) per hour.
15. Ensure that final grades are achieved as specified, taking into account the mulch layer that will be added after planting. Fine grading is extremely important for rain garden facilities. They are typically only 6 in (150mm) deep so an error of 2 in (50mm) may cause a 33% change in storage volume.
16. Install vegetation specified in the planting plan.
17. Install a 3 in (75mm) FilterMedia blanket as mulch over the entire rain garden area, or as specified by the Engineer. Install erosion control at entrance points in the form of surge stone or river rock, or as specified.
18. New planting may require irrigation during establishment. See design drawing details for correct rain garden installation (Figure 7.1 through 7.3).

INSPECTION

Regular inspection should occur throughout the installation process at the following times:

1. Pre-construction meeting.
2. Stabilization of construction site and beginning of excavation.
3. Installation of underdrain.
4. Delivery and installation of soil materials, including GrowingMedia.
5. Establishment of final grades of rain garden facility.
6. Delivery and installation of plant material.
7. Delivery and installation of FilterMedia blanket or mulch.
8. Establishment phase of plant material.

MAINTENANCE

1. The Contractor shall ensure that the site upstream from the rain garden area remains stabilized and does not contribute excessive sediment that may impair the performance of the rain garden area.
2. Plant materials may need to be irrigated during establishment.

3. Plant materials that do not establish, may need to be replaced.
4. The rain garden facility should be monitored for invasive non-native plant species. Any that are found should be eradicated.
5. FilterMedia should be replaced as necessary to ensure complete coverage of the surface of the rain garden area.

METHOD OF MEASUREMENT

Bid items shall show measurement as 'Filtrexx® Rain Garden' per square ft, square yd, square m, hectare, or acre installed, per depth (in. or mm) of system.

Engineer shall notify Filtrexx of location, description, and details of project prior to the bidding process so that Filtrexx can provide design aid and technical support.

FIELD APPLICATION PHOTO REFERENCES

GrowingMedia Installation Method

Completed Rain Garden

Rain Garden Installed with GroSoxx (Soxx Mesh & GrowingMedia)

Rain Garden with GroSoxx, One Year After Installation

ADDITIONAL INFORMATION

For other references on this topic, including additional research reports and trade magazine and press coverage, visit the Filtrexx website at filtrexx.com

Filtrexx International, Technical Support
877-542-7699 | www.filtrexx.com | info@filtrexx.com
Call for complete list of international installers and distributors.

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Table 7.1. Filtrexx SiltSoxx® Mesh Material Specifications.

Material Type	**NATURAL ORIGINAL** (Cotton Fiber)	**NATURAL PLUS** (Wood Fiber)	**BASIC** (5 mil High Density Polyethylene HDPE)	**BASIC PLUS** (Multi-Filament Polypropylene MFPP)	**DURABLE** (Multi-Filament Polypropylene MFPP)	**ORIGINAL / DURABLE PLUS / DURASOXX HD** (Multi-Filament Polypropylene MFPP)	**EXTREME** (Multi-Filament Polypropylene MFPP)
Material Characteristic	Biodegradable	Biodegradable	Photodegradable	Photodegradable	Photodegradable	Photodegradable	Photodegradable
Design Diameters	5 in (125mm), 8 in (200mm), 12 in (300mm)	5 in (125mm), 8 in (200mm), 12 in (300mm)	8 in (200mm), 12 in (300mm), 18 in (400mm)	8 in (200mm), 12 in (300mm), 18 in (400mm), 24 in (600mm), 32 in (800mm)	5 in (125mm), 8 in (200mm), 12 in (300mm), 18 in (400mm), 24 in (600mm), 32 in (800mm)	5 in (125mm), 8 in (200mm), 12 in (300mm), 18 in (400mm), 24 in (600mm)	8 in (200mm), 12 in (300mm)
Mesh Opening	1/8 in (3mm)	1/8 in (3mm)	3/8 in (10mm)	3/8 in (10mm)	1/8 in (3mm)	1/8 in (3mm)	1/16 in (1.5mm)
Tensile Strength (ATSM D4595)[1]	MD: 193 lbs TD: 158 lbs	MD: 210 lbs TD: 289 lbs	MD: 211 lbs TD: 79 lbs	MD: 236 lbs TD: 223 lbs	MD: 545 lbs TD: 226 lbs	MD: 670 lbs TD: 423 lbs	MD: 1062 lbs TD: 797 lbs
% Original Strength from Ultraviolet Exposure (ASTM G-155)	ND	ND	23% at 1000 hr	100% at 1000 hr	100% at 1000 hr	100% at 1000 hr	100% at 1000 hr
Functional Longevity/ Project Duration[2]	up to 12 months[3]	up to 18 months[4]	up to 4 yr	up to 4 yr	up to 5 yr	up to 5 yr	up to 5 yr

[1] Tensile Strength is based on 12" diameter using ATSM D4595. See Filtrexx TechLink #3342 for full tensile strength testing.
[2]Functional longevity ranges are estimates only. Site specific environmental conditions may result in significantly shorter or longer time periods.
[3]Data based on Caltrans research and specifications
[4] See TechLink #3339 for research & testing

Source: USDA-SCS, 1986; *From Chow et al. (1988).

Table 7.2. USDA Soil Conservation Service Runoff Curve Numbers.

Description of Land Use	Hydrologic Soil Group			
	A	B	C	D
Paved parking lots, roofs, driveways	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Cultivated (Agricultural Crop) Land*:				
Without conservation treatment (no terraces)	72	81	88	91
With conservation treatment (terraces, contours)	62	71	78	81
Pasture or Range Land:				
Poor (<50% ground cover or heavily grazed)	68	79	86	89
Good (50-75% ground cover; not heavily grazed)	39	61	74	80
Meadow (grass, no grazing, mowed for hay)	30	58	71	78
Brush (good, >75% ground cover)	30	48	65	73
Woods and Forests:				
Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Fair (grazing but not burned; some brush)	36	60	73	79
Good (no grazing; brush covers ground)	30	55	70	77
Open Spaces (lawns, parks, golf courses, cemeteries, etc.):				
Fair (grass covers 50-75% of area)	49	69	79	84
Good (grass covers >75% of area)	39	61	74	80
Commercial and Business Districts (85% impervious)	89	92	94	95
Industrial Districts (72% impervious)	81	88	91	93
Residential Areas:				
1/8 Acre (0.05 ha) lots, about 65% impervious	77	85	90	92
1/4 Acre (0.1 ha) lots, about 38% impervious	61	75	83	87
1/2 Acre (0.2 ha) lots, about 25% impervious	54	70	80	85
1 Acre (0.4 ha) lots, about 20% impervious	51	68	79	84

Source: USDA-SCS, 1986; *From Chow et al. (1988).

Figure 7.1. Typical Rain Garden Cross-Section.

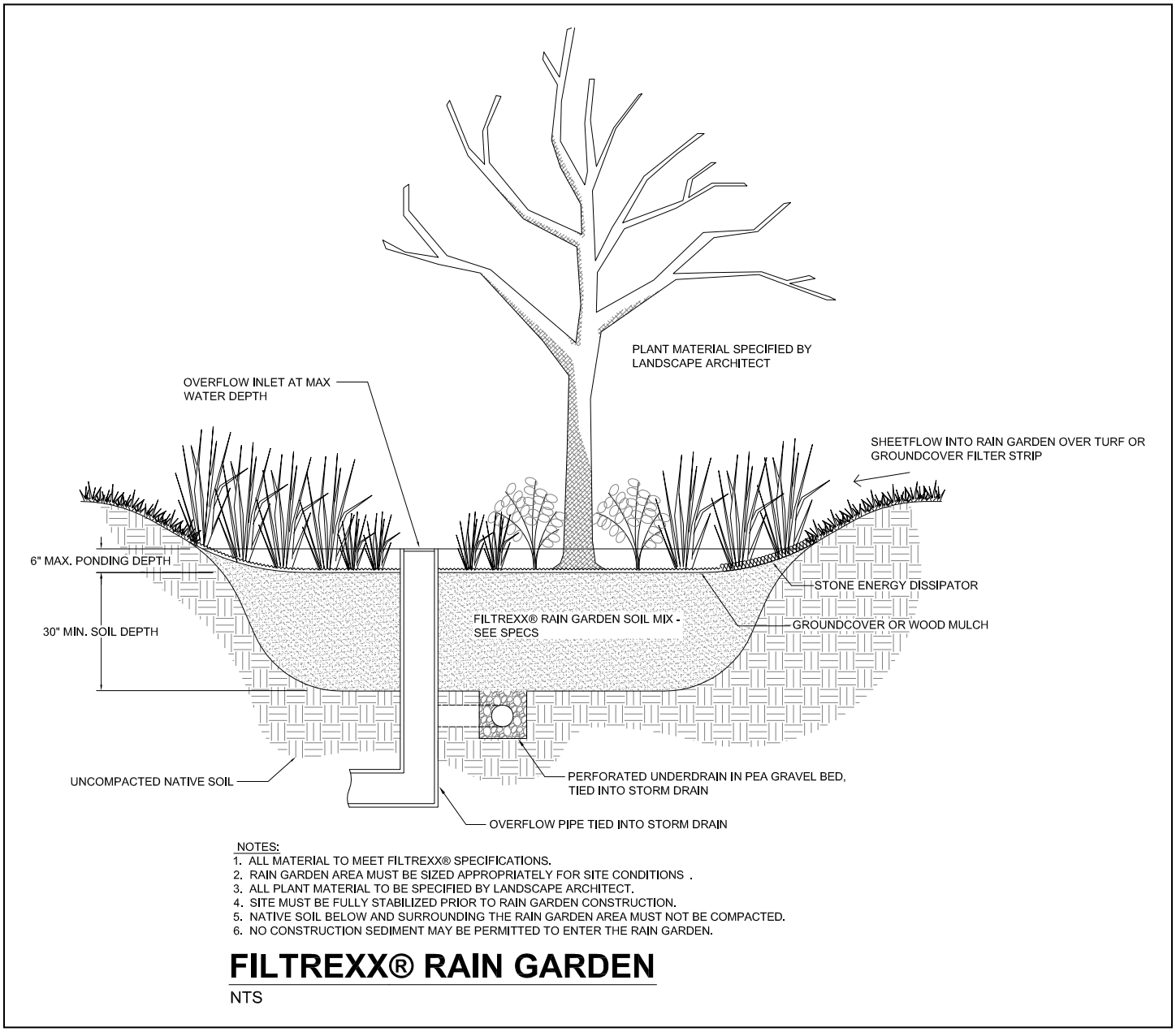

Figure 7.2. Rain Garden Placement on a Residential Site.

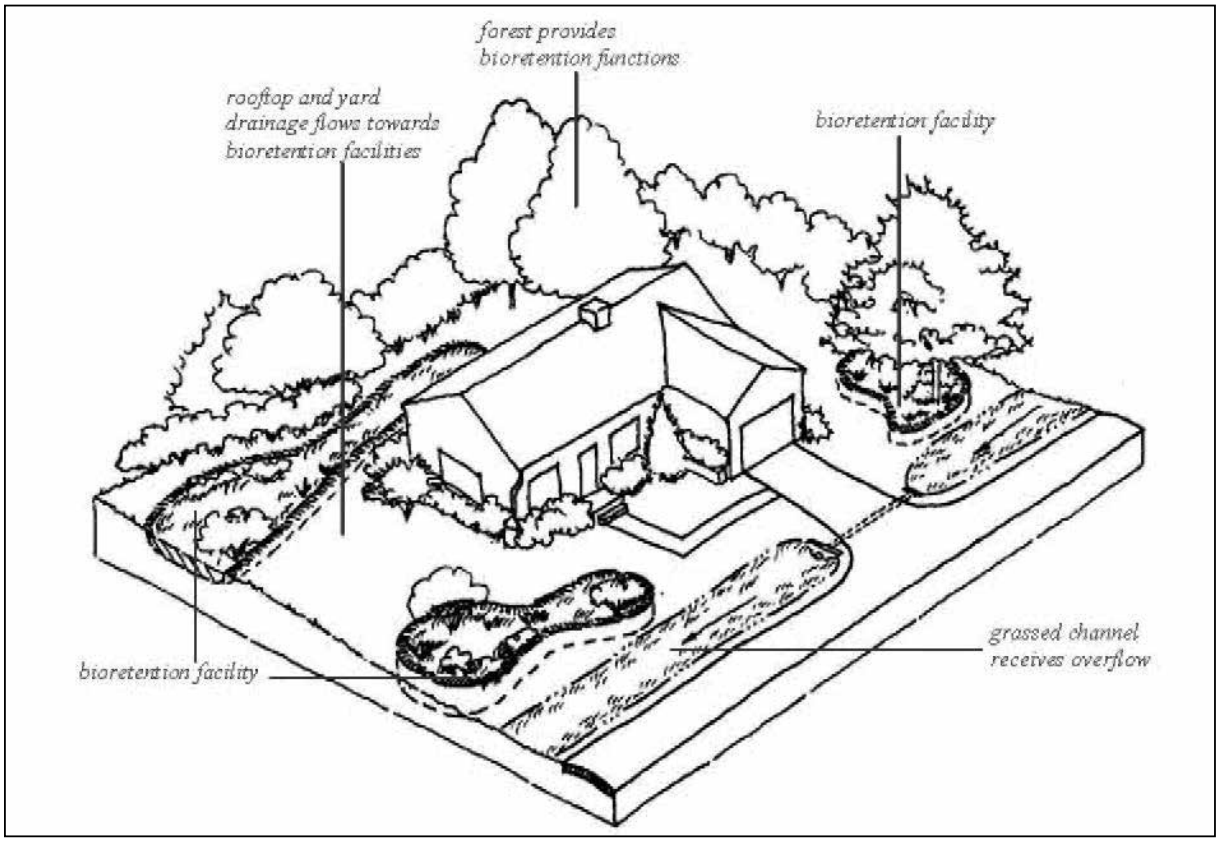

Figure 7.3. Rain Garden Placement in a Parking Lot.