Bioretention Design

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North Central Texas Council of Governments

Agenda

15 min.: **Basics of Bioretention**

20 min: **Design Standards and Criteria**

15 min: **Maintenance and Inspection**

10 min: **Bioretention in the Region**

Basics of Bioretention

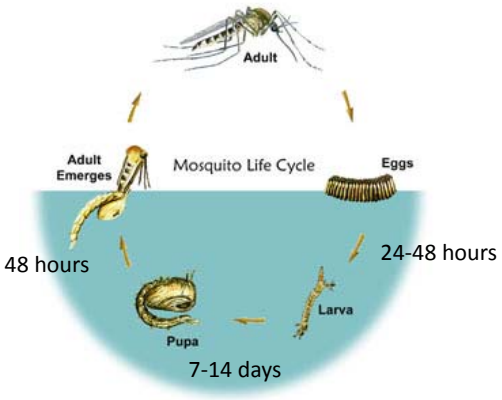
- Also called rain gardens
- Treatment through filtration, infiltration, and biological
- Applicable to small drainage areas. Less than 2 acres recommended with maximum of 5 acres

Charlotte-Mecklenberg Stormwater Services

- Length to width ratio of 2:1
- Drain time of less than 48 hours

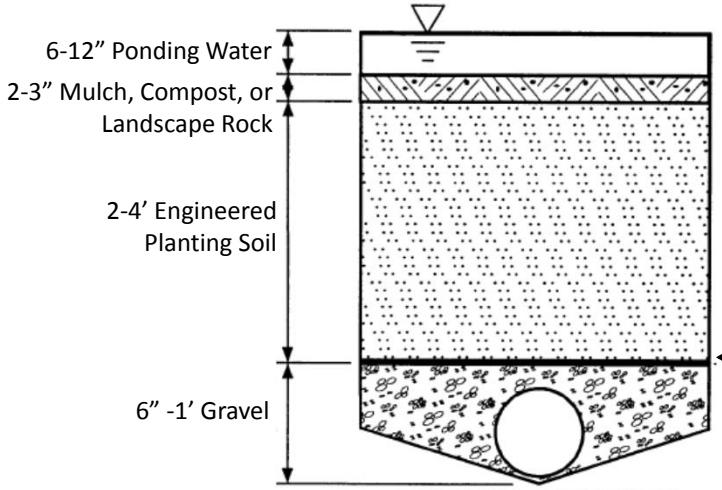
Basics of Bioretention

- **Common questions**
  - Will using bioretention create breeding grounds for mosquitos?

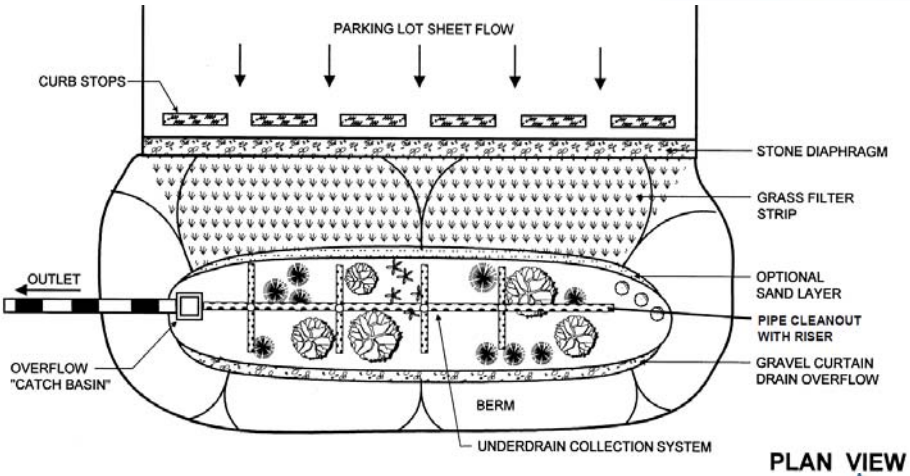


- Mosquito eggs and larva are aquatic, need water to survive.
- If water dries out, eggs die.
- The required drawdown rates drain the water before a pupa can develop.

Basics of Bioretention



Basics of Bioretention



Basics of Bioretention

NCDENR Stormwater BMP Manual 07/09

Basics of Bioretention

iSWM Technical Manual 04/10

Basics of Bioretention

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Basics of Bioretention

NCDENR Stormwater BMP Manual 07/09

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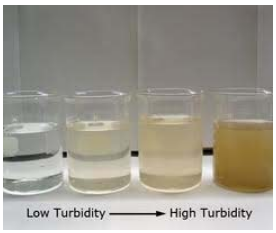
Basics of Bioretention

Nemo.uconn.edu

Basics of Bioretention

Efficiency

80%	Total Suspended Solids
60%/50%	Nutrients (Total Phosphorus/Total Nitrogen)
80%	Metals (Cadium, Copper, Lead, and Zinc
No Data	Pathogens (Coliform, Streptococci, E. Coli)



Basics of Bioretention

- How to Calculate the Water Quality Volume

1. Calculate the volumetric runoff coefficient

$$R_v = 0.05 + 0.009(I)$$

where I = percent of impervious cover (%)

2. Calculate the water quality volume (WQ_v)

$$WQ_v = \frac{1.5\, R_v\, A}{12}$$

where:
WQ_v = water quality protection volume (acre-feet)
R_v = volumetric runoff coefficient
A = total drainage area (acres)

Basics of Bioretention

Calculating the area of bioretention:

- Use Darcy's Law equation to determine the required ponding area

$$A_f = \frac{(WQ_v)(d_f)}{[(k)(h_f + d_f)(t_f)]}$$

Where:

A_f = surface area of ponding area (ft^2)

WQ_v = water quality volume (ft^3) [1 acre-feet = 43,560 cubic feet]

d_f = Engineered planting soil depth (ft) [2 to 4 ft]

k = design coefficient of permeability for filter media (ft/day) [use 0.5 ft./day to as a conservative design rate for bioretention soil infiltration]

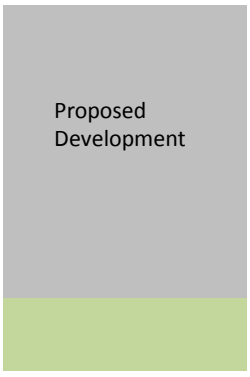
h_f = average height of water above filter bed (ft) [typically half of max depth]

t_f = design filter bed drain time (days) [2 days or 48 hours recommended]

Basics of Bioretention

Bioretention Exercise (10 min.)

A commercial development is being planned for a **5 acre** lot with an equivalent drainage area and **80% proposed impervious cover**. They plan on treating their water quality volume with a bioretention pond. Assume a **filter bed depth of 3 feet** and a **max ponding depth of 6 inches**.



What is the water quality volume?

What is the required area of a bioretention pond?

Basics of Bioretention

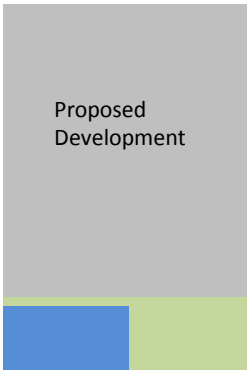
Bioretention Exercise

Step 1) Determine the water quality volume

$$WQ_v = \frac{1.5\,(0.77)\,(5)}{12} = 0.48\ acre\ ft$$

Step 2) Determine the surface area of the ponding area

$$A_f = \frac{(20,909)(3)}{[(0.5)(0.25+3)(2)]} = 19,300\ sq.ft.$$



With 2:1 ratio requirement area should be approx. **196.5 ft by 98.25 ft**

Basics of Bioretention

Cost of Bioretention

EPA Cost Estimate = 7.30 * V $^{0.99}$

where: V = bioretention volume in cubic feet

For example problem: 7.30 * 20,909$^{0.99}$ = $138,182

Cost savings:

Curb, Inlets, Pipe, etc.

Design Standards and Criteria

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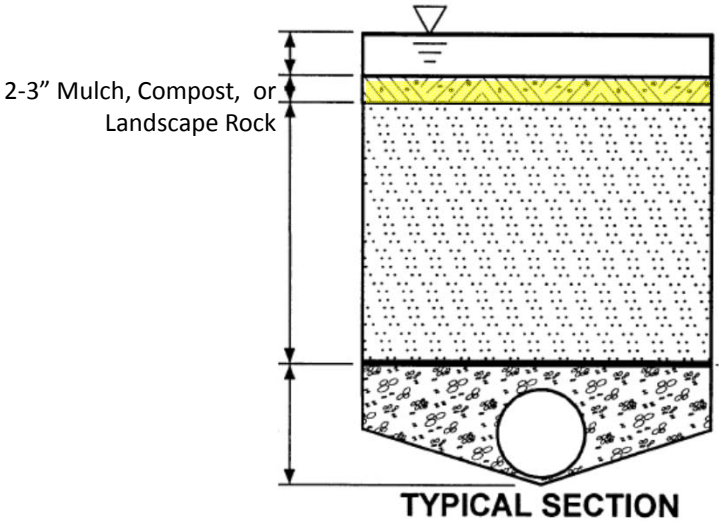
Design Standards and Criteria



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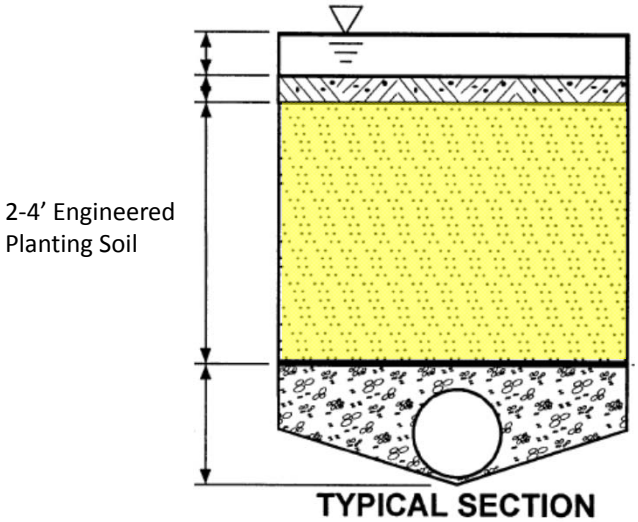
Design Standards and Criteria

Mulch Standards

- Commercially available double or triple shredded and screened hardwood mulch or chips
- Stock piled or stored for 6 to 12 months
- No soil or fine organics
- No grass clippings or pine straw
- Uniform in color

Design Standards and Criteria



Design Standards and Criteria

Engineered Soil Standards

- Minimum of 2 feet deep. 4 feet if trees are present.
- Locate on A or B soils where possible
- Free of stones, lumps, or roots larger than 2”
- Sandy loam, loamy sand, or loam texture
- Sand content of 50-60%
- Leaf compost content of 20-30%
- Topsoil content of 20-30%
- Clay content of 5 to 8%
- Organic content (such as peat moss)of 1.5 to 3%

Design Standards and Criteria

Engineered Soil Standards

- Infiltration rate of at least 0.5 in/hr to 1.5 in/hr (1.0 ft/day to 3.0 ft/day)
- pH between 5.5 and 7.0
- Maximum soluble salt concentration of 500ppm
- Uniform mix
- Required tests include a sieve analysis, pH, and organic matter test
- Phosphorus index between 10 and 30

Design Standards and Criteria

Engineered Soil Standards

PARAMETER	ACCEPTABLE VALUES		TESTING REQUIRED *	TEST METHODS
Sand Content (ASTM C-144 recommended)	80%		No	-
Organic Material (compost, sandy loam, and loamy sand)	20%		No	TMECC 05.07-A
Clay Content	Less than 6%		No	-
Phosphorus Index (total Phosphorus)	10 to 30 (12 to 36 ppm on a dry basis)		Yes	Mehlich 3 Extraction, Mehlich 2 Extraction (Mehlich 1 Extraction is acceptable but result must be multiplied by 1.7 for comparison)
pH	5.5 to 7.0		No	TMECC 04.11-A
Permeability	1 to 4 in/hr		No	ASTM D2434 (compacted to 20%)
Particle Size Analysis	Acceptable % Passing by Weight		Yes	ASTM D422
	Lower	Upper		
Sieve 2 inch (50 mm)	100	100		
Sieve No. 4 (4.75 mm)	98	100		
Sieve No. 8 (2.36 mm)	95	100		
Sieve No. 10 (2.0 mm)	86	100		
Sieve No. 16 (1.18 mm)	70	100		
Sieve No. 30 (600 um)	40	75		
Sieve No. 50 (300 um)	10	35		
Sieve No. 100 (150 um)	2	15		
Sieve No. 200 (75 um)	0	10		

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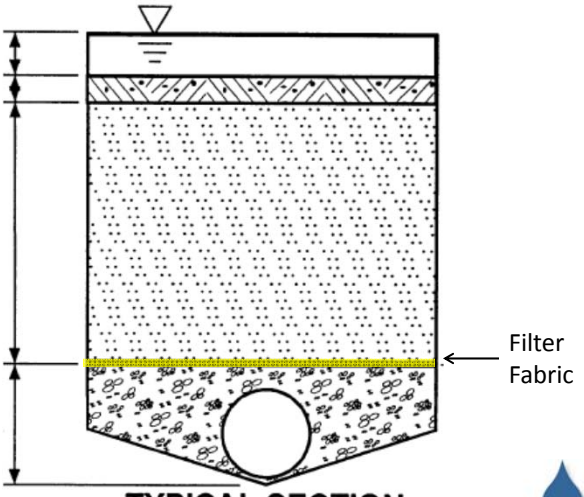
Design Standards and Criteria

Alternative:

- choking stone of washed pea gravel
- 4 to 9” layer above gravel
- ASTM D448 size No. 6, $^1/_8$” to ¼”)
- 24” wide section of filter fabric placed between the gravel layer and pea gravel layer directly above the underdrain pipe



TYPICAL SECTION

Design Standards and Criteria

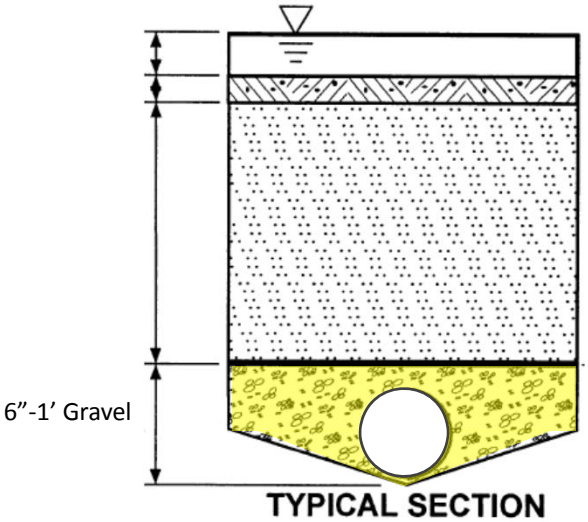
Filter Fabric Standards

- Placed over the gravel layer and along sloping outer walls to limit infiltration before filtration and to prevent lateral flow under pavement
- Filter fabric shall be non-woven
- Minimum permittivity rate of 75 to 125 gal/min/ft^2

Geotextile Property	Value	Test Method
Trapezoidal Tear (lbs)	40 (min)	ASTM D4533
Permeability (cm/sec)	0.2 (min)	ASTM D4491
AOS (sieve size)	#60 - #70 (min)	ASTM D4751
Ultraviolet resistance	70% or greater	ASTM D4355

City of Santa Barbara Stormwater BMP Guidance Manual, June 2008

Design Standards and Criteria



Design Standards and Criteria

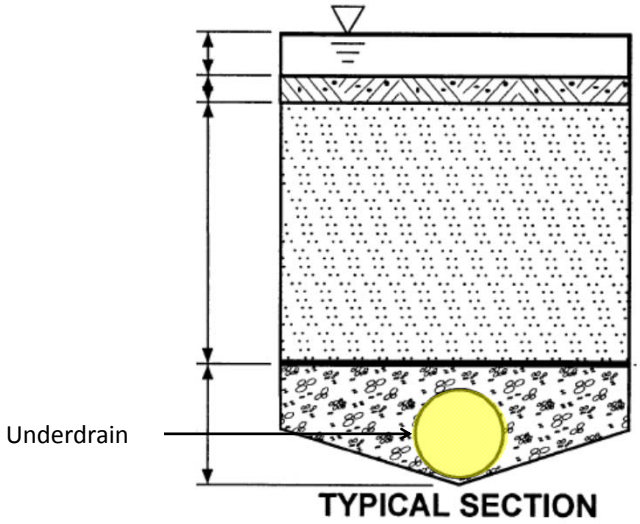
Gravel Layer Standards

- Creates positive drainage, keeps underdrain free of sediment, aerobic conditions in the planting soil, and provides final polishing treatment.
- Gravel should be #57 (½”– 1 ½”), double washed.
- AASHTO M-43 specification
- Drawdown within 72 hours

Sieve size	Percent Passing
¾ inch	100
¼ inch	30-60
US No. 8	20-50
US No. 50	3-12
US No. 200	0-1

City of Santa Barbara Stormwater BMP Guidance Manual, June 2008

Design Standards and Criteria



Design Standards and Criteria

Underdrain Standards

- 6-inch perforated PVC pipe, rigid Schedule 40 (AASHTO M 278)
- 3/8-inch perforations, spaced at 6-inch centers, with a minimum 4 holes per row
- Pipe spaced at a maximum of 10 feet on center
- Minimum grade of 0.5%
- Assume 50% capacity loss due to clogging

Design Standards and Criteria

Underdrain Cleanout Standards

- 6-inch solid PVC cleanouts provided every 50 linear feet, at all bends, and ends of system
- Top of cleanouts should extend 6-inches above maximum ponding elevation
- One cleanout installed as emergency drain, even with top of mulch layer with a 6-inch threaded extension pipe
- All cleanouts shall have watertight, vandal-proof caps

Design Standards and Criteria

Landscaping Standards

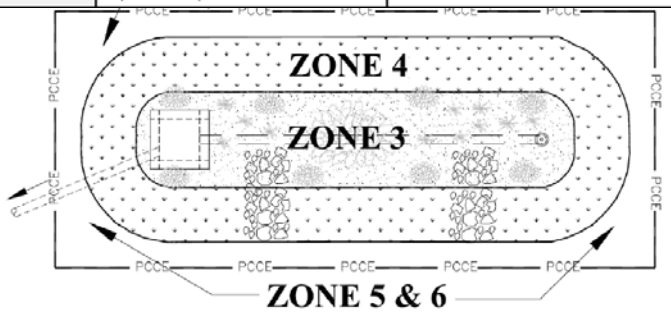
- Tree-to-shrub ratio of 2:1 or 3:1
- Trees placed 8 feet apart
- Plants should be resistant to drought and inundation

Design Standards and Criteria

Commonly Used Species for Bioretention Areas		
Trees	**Shrubs**	**Herbaceous Species**
Acer rubrum Red Maple (Zones 2, 3, 4)	*Amorpha fruticosa* False Indigo (Zones 3, 4)	*Andropogon virginicus* Broom Sedge/ Grass (Zone 4)
Betula nigra River Birch (Zones 4, 5)	*Aronia arbutifolia* Red Chokeberry (Zones 2, 3)	*Eupatorium fistolosum* Joe Pye Weed (Zone 4)
Cercis canadensis Eastern Redbud (Zones 4, 5)	*Callicarpa Americana* American Beautyberry (Zones 4, 5)	*Iris pseudacorus* Yellow Iris
Crataegus reverchonii Reverchon's Hawthorn (Zone 6)	*Hamemelis virginiana* Witch Hazel (Zone 5)	*Lobelia cardinalis* Cardinal Flower (Zone 3)
Juglans nigra Black Walnut (Zone 6)	*Lindera benzoin* Spicebush	*Malvaviscus drummondii* Turk's Cap (Zones 4, 5, 6)
Juniperus virginiana Eastern Red Cedar (Zones 5, 6)	*Myrica pennsylvanica* Bayberry	*Panicum capillare* Witchgrass (Zones 3, 4, 5, 6)
Platanus occidentalis Sycamore	*Prunus mexicana* Mexican Plum (Zones 5, 6)	*Panicum virgatum* Switchgrass (Zone 2)
Quercus phellos Willow Oak (Zones 3, 4, 5)	*Rhamnus caroliniana* Carolina Buckthorn (Zones 4, 5, 6)	*Pennisetum alopecuroides* Fountaingrass (Zone 6)
Quercus macrocarpa Bur Oak (Zones 5, 6)	*Viburnum rufidumlum* Rusty Blackhaw (Zones 4, 5, 6)	*Rudbeckia hirta* Black Eyed Susan (Zone 4)

Design Standards and Criteria

Zone #	Zone Description	Hydrologic Conditions
Zone 1	Deep Water Pool	1-6 feet depth (permanent pool)
Zone 2	Shallow Water Bench	Normal pool elevation to 1 foot depth
Zone 3	Shoreline Fringe	Regularly inundated
Zone 4	Riparian Fringe	Periodically inundated
Zone 5	Floodplain Terrace	Infrequently inundated
Zone 6	Upland Slopes	Seldom or never inundated



FREESE AND NICHOLS

Maintenance and Inspection

North Central Texas Council of Governments

iSWM

Maintenance and Inspection

NCTCOG iSWM Manual

Table 2.1 Typical Maintenance Activities for Bioretention Areas

Activity	Schedule
• Pruning and weeding to maintain appearance. • Mulch replacement when erosion is evident. • Remove trash and debris.	As needed
• Inspect inflow points for clogging (off-line systems). Remove any sediment. • Inspect filter strip/grass channel for erosion or gullying. Re-seed or sod as necessary. • Trees and shrubs should be inspected to evaluate their health and remove any dead or severely diseased vegetation.	Semi-annually
• The planting soils should be tested for pH to establish acidic levels. If the pH is below 5.2, limestone should be applied. If the pH is above 7.0 to 8.0, then iron sulfate plus sulfur can be added to reduce the pH.	Annually
• Replace mulch over the entire area. • Replace pea gravel diaphragm if warranted (or when the voids are obviously filled with sediment and water is no longer infiltrating).	2 to 3 years

(Source: EPA, 1999)

Maintenance and Inspection

North Carolina Division of Water Quality

12.4.2. Sample Operation and Maintenance Provisions

Important operation and maintenance procedures:

- Immediately after the bioretention cell is established, the plants will be watered twice weekly if needed until the plants become established (commonly six weeks).
- Snow, mulch or any other material will NEVER be piled on the surface of the bioretention cell.
- Heavy equipment will NEVER be driven over the bioretention cell.
- Special care will be taken to prevent sediment from entering the bioretention cell
- Once a year, a soil test of the soil media will be conducted.

After the bioretention cell is established, I will inspect it **once a month and within 24 hours after every storm event greater than 1.0 inches (or 1.5 inches if in a Coastal County)**. Records of operation and maintenance will be kept in a known set location and will be available upon request.

Inspection activities shall be performed as follows. Any problems that are found shall be repaired immediately.

Maintenance and Inspection

Prince George's County, Maryland – Bioretention Manual

- Sequence of Construction for Bioretention
- Bioretention Inspection Checklist
- Bioretention Plan Review Checklist

Sequence of Construction For Bioretention

1. Install sediment control devices as shown on the plans.
   -Construction time: _____ Day(s)

2. Grade site to elevations shown on plan. If applicable, construct curb openings, and/or remove and replace existing concrete as specified on the plan. Curb openings shall be blocked or other measures taken to prohibit drainage from entering construction area. At the end of each workday, all excavations shall be protected by construction safety fencing or temporary backfill as needed.
   -Construction time: _____ Day(s)

3. Stabilize grading within Limit of Disturbance except for Bioretention Area. Bioretention areas may be utilized as sediment traps *if* the proposed invert of the bioretention facility is 1' lower then the sediment trap.
   -Construction time: _____ Day(s)

4. Excavate bioretention area to proposed invert depth and scarify the existing soil surfaces, taking care not to compact the in-situ materials.
   -Construction time: _____ Day(s)

4a. Install underdrain system and observation wells, if specified
   -Construction time: _____ Day(s)

5. Backfill bioretention area with planting soil as shown in the plans and detailed in the specifications. Overfilling is recommended to account for settlement.
   -Construction time: _____ Day(s)

6. Presoak the planting soil prior to planting vegetation to allow for settlement. This can be done by water truck or allowing water to enter the pit from a rain event.
   -Construction time: _____ Day(s)

7. Excavate or fill to achieve proper design grade, leaving space for the upper layer of mulch and/or topsoil that will bring the surface to final grade and ready for planting.
   -Construction time: _____ Day(s)

8. Plant vegetation specified in the planting plan for Bioretention Area.
   -Construction time: _____ Day(s)

9. Mulch and install erosion protection at entrance points; remove sediment control practices or entrance blocks with inspector authorization.
   -Construction time: _____ Day(s)

Total Estimated Construction Time: _____ Day(s)

Note: The times above represent construction time only and not the full duration of the individual activities. For example, activity six (presoak) may be one month long allowing for natural settlement to occur before proceeding to activity 7.

4.17 Inspectors Checklist for Bioretention

The following checklist has been derived and modified from a checklist developed by the Community Standards Division, Site Development Inspection Section for use when evaluating a bioretention facility during different phases:

4.17.1 Bioretention Inspection Checklist

1. Pre-construction Meeting

- ✍ Approved Stormwater Management Plan
- ✍ Disseminate inspection requirements; what needs inspection
- ✍ Ticket and tag requirements & a copy of the geotechnical report (if available)

2. Excavation of Bioretention Area

- ✍ Suitable sub-grade materials
- ✍ Presence of moisture or water
- ✍ Dimensions and placement of excavation conforms with plans
- ✍ Sediment and erosion control devices in place

3. Installation Phase

- ✍ Optional sand layer placed per plan
- ✍ Backfill soil conforms with specifications and placed per details and specifications
- ✍ Correct placement of ground cover or mulch cover
- ✍ Correct placement of underdrains (size, schedule, location) where required
- ✍ Correct placement of filter fabric
- ✍ Proper placement of plant materials (type, size, quantity, tags)
- ✍ Proper grade establishment

4. Final Inspection and As-Built

- ✍ Original signed/sealed Certification Letter (for private facilities) and/or As-Built Plan (for public facilites) from a Maryland Registered Professional Engineer
- ✍ Changes in grading, facility depth, size, soil medium, plant materials, etc., shall require an As-built Plan whether private or public to reflect the changes.
- ✍ Maintenance Agreement/Covenant for bioretention facilities located on private property
- ✍ All landscaping installed/landscape warrantee documentation received
- ✍ Bioretention configuration, size and depth are in accordance with approved plans
- ✍ Landscaping certification documentation for bioretention facility(ies)
- ✍ Drainage area conforms to approved plan
- ✍ Drainage area completely stabilized

2.16 Bioretention Site Submittal Requirements

BIORETENTION PLAN REVIEW CHECKLIST

Project Name: _____ Date Received: _____
Project Address:_____
Case #:_____

Accepted – **Not Accepted** – **N/A**

Plan Standard Notes & Specifications

_____ _____ _____ Notes on sediment & erosion controls.
_____ _____ _____ Sequence of Construction.
_____ _____ _____ Sediment control notes for bioretention facilities during construction.
_____ _____ _____ Specifications for construction materials.
_____ _____ _____ Specifications for planting soil medium requirements.
_____ _____ _____ Compaction Notes.
_____ _____ _____ Easements.
_____ _____ _____ Copy of concept letter.
_____ _____ _____ Storm drain notes.
_____ _____ _____ Stormwater management construction specifications.

Plan Layout

_____ _____ _____ Vicinity map.
_____ _____ _____ Owner / developer information.
_____ _____ _____ Approval box.
_____ _____ _____ Plan view of site & facilities.
_____ _____ _____ Cross-section along centerline of bioretention.
_____ _____ _____ Cross-section along stormdrain or flow path.
_____ _____ _____ Existing grades and proposed grades.
_____ _____ _____ Elevation at surface, ponding elevation.
_____ _____ _____ Standard detail for bioretention.
_____ _____ _____ Landscaping plan.
_____ _____ _____ Soil map.
_____ _____ _____ Inflow and discharge points/connections.

Drainage Area to Facilities

_____ _____ _____ DAM delineated to each facility.
_____ _____ _____ Drainage area less than 2 acres max.
_____ _____ _____ Facilities located near source.
_____ _____ _____ Facilities not to be placed where concentrated water discharge exceeds 3 cfs.

Grading

_____ _____ _____ Existing and proposed contours with limits of disturbance.
_____ _____ _____ Spot elevations at entrance invert.
_____ _____ _____ Underdrain invert elevation and facility invert elevation.
_____ _____ _____ ½ inch contours for detail at facility.
_____ _____ _____ Not crossing properties and 2-foot min. from property lines.
_____ _____ _____ Not to be built in public right of ways.
_____ _____ _____ Not to be built where wooded areas would need to be cleared to make room for the facility.
_____ _____ _____ Sloped areas exceeding 20% shall not be used for bioretention except "weep-gardens" designs.
_____ _____ _____ 25 ft. setback from the home foundation.

Facility Components

_____ _____ _____ Pretreatment - Erosion protection: RipRap, Reno mattress, etc.
_____ _____ _____ Flow entrance – Curb cut, curb deflector, pipe outfall, etc.
_____ _____ _____ Ponding area – depth 6 inch max.
_____ _____ _____ Planting soil medium – 50% construction sand, 20-30% organic leaf compost, and 20-30% topsoil with a max. of 5% clay content.
_____ _____ _____ Mulch and/or groundcover
_____ _____ ____ Filtering mechanism
- Gravel & Filter Cloth
- Peagravel
- Other _____

_____ _____ _____ Underdrain or outlet - Approved pipe material, pipe size perforation size.
_____ _____ _____ Safe overflow allowance

Design Computations

_____ _____ ____ Facilities designed for water quality and/or water quantity control
_____ _____ ____ Method of Sizing:
MD Unified Sizing Methodolgy _____
Prince George's LID Methodolgy _____
Prince George's % DA Methodology _____
_____ _____ ____ Post Development RCN Value
_____ _____ ____ Geotechnical Report.

Landscaping Detail

_____ _____ ____ Plan view of landscaping.
_____ _____ ____ Plant list.
_____ _____ ____ Planting notes.
_____ _____ ____ Planting schedule and specifications.
_____ _____ ____ Standard detail for planting.
_____ _____ ____ Use bioretention plant list – (No exotic or invasive plants).

Permitting

_____ _____ ____ Sediment / Erosion Control.
_____ _____ ____ Stormdrain permit for construction.
_____ _____ ____ Easement or Maintenance Covenant

COMMENTS:_____
_____
_____
_____
_____
_____

First Review: **Reviewer**_____ **Date**_____
Please complete all items checked "Not Accept" and return with corrections.

Second Review: **Reviewer**_____ **Date**_____
Please complete all items checked "Not Accept" and return with corrections.

✍ I hereby approve all items listed above being completed as per County specifications.

Reviewer'sSignature_____ Date_____

BIORENTENTION INSPECTION CHECKLIST

Sign and date each phase of construction, as each one is completed. This is to confirm that each phase was completed in compliance with County approved plans and specifications. Refer to the Bioretention Guidelines located in The Bioretention Manual for any questions on bioretention installation and specifications.

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1) Arrange a pre-construction meeting with the County Inspector. Review sequence of construction, dimensions and location of the facility, soil specifications and landscaping, and required inspections and certifications.

   ✍ ***Required Inspections:*** ***Site engineer shall be present during the construction of the facility in order for the engineer to certify the installation and completion of the facility. The following inspections shall be approved in writing by the County inspector prior to proceeding to next activity.***

Contractor/Developer **Inspector**

Excavation of Bioretention Area

1) Inspect the subgrade for proper depth, permeability, and presence of water. Also inspect the dimensions and location of the area for conformity with the approved stormdrain plan.

Contractor/Developer **Inspector**

Installation

1) Scarify the bottom and sides of the facility before installation of any materials. Inspect correct placement of the underdrain system, which includes pipe size, perforations, pipe schedule, gravel bedding, filter cloth, and location of system.
   * ***Inspectors must obtain tickets for materials used in the installation of the underdrain.***

2) Inspect the planting soil medium for conformity with specifications and placed per details and specifications. Avoid compaction of the soil.
   * ***A soil certification for the planting soil medium will be required by the inspector.***

3) Inspect for proper placement of mulch layer. Also inspect for proper placement of landscaping, including type, size, and quantity of plants.
   * ***Inspectors must obtain tags for planting materials to verify plantings.***

4) Inspect proper pooling depth of the facility.

Contractor/Developer **Inspector**

Final Inspection

1) Inspect the bioretention configuration, size, and depth are in accordance with approved plans.

2) Inspect the landscaping to verify compliance with approved plans.

3) Drainage area must conform to approved plan. Drainage area must be permanently stabilized. Sediment controls devices shall remain in place until the contributing drainage area to the bioretention facilities is permanently stabilized.

? For final inspection of a private facility, submit a copy of the Maintenance Agreement/Covenant and an original signed/sealed certification letter from a Maryland registered professional engineer for the completed facility. If any changes to the facility (location, size, etc.), approved As-Builts are required.

- OR -

? For final inspection of a public facility, submit a certified As-Built plan, original landscaping certification, and release of liens.

Contractor/Developer **Inspector**

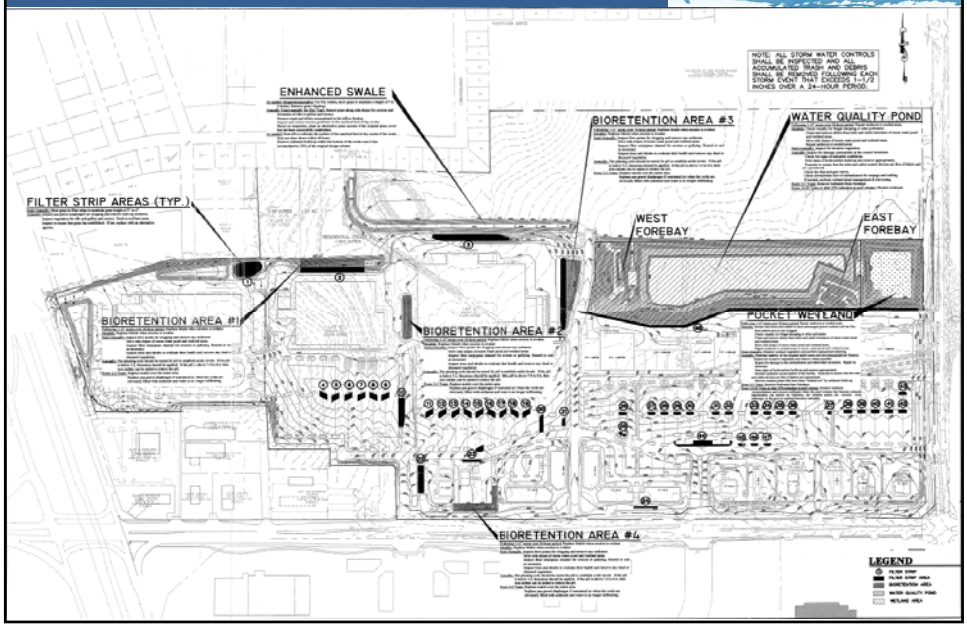
COMMENTS:

Bioretention in the Region

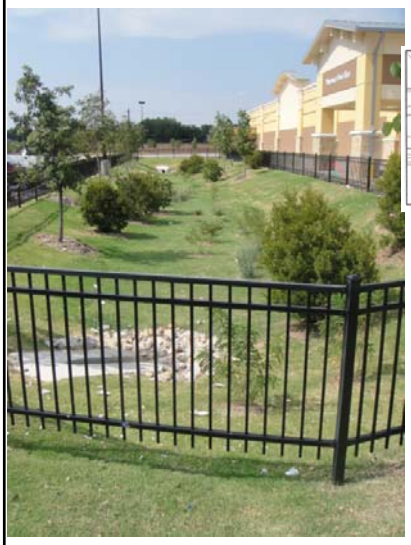
North Central Texas Council of Governments

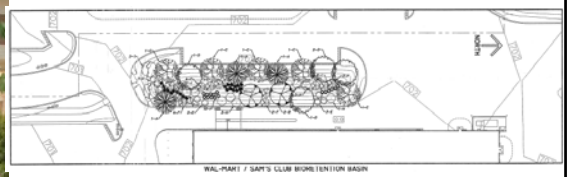
iSWM

Rayzor Ranch, Denton



Rayzor Ranch, Denton





WAL-MART / SAM'S CLUB BIORETENTION BASIN

PLANT MATERIAL LIST — FULLY ROOT NEWLY STRIPPED PLANTS NOT ACCEPTABLE — THIS CHART IS FOR REFERENCE ONLY. CONTRACTOR SHOULD VERIFY QUANTITIES AS SHOWN ON PLAN.

SYMBOL	KEY	COMMON/SCIENTIFIC NAME	QUANTITY	CALIPER	HEIGHT	SPREAD	ROOT	REMARKS
	A.	BALD CYPRESS *Taxodium distichum*	13	2"	9'-12'	4'-6'	CONTAINER	SINGLE TRUNK
	B.	RED OAK *Quercus shumardii*	20	2"	9'-12'	4'-7'	CONTAINER	SINGLE OR MULTI TRUNK
	C.	CEDAR ELM *Ulmus crassifolia*	26	2"	9'-12'	4'-7'	CONTAINER	SINGLE OR MULTI TRUNK
	D	SUR OAK *Quercus macrocarpa*	16	2"	9'-12'	4'-7'	CONTAINER	SINGLE TRUNK
	E	FALSE INDIGO *Amorpha fruticosa*	71	N/A	2'-4'	2'-3'	• 5 gal.	
	F	WAX MYRTLE *Myrica cerifera*	65	N/A	3'-6'	4'-6'	CONTAINER	MULTI TRUNK
	G	RED BUD *Cercis canadensis*	19	1"-2"	6'-8'	4'-5'	CONTAINER	SINGLE OR MULTI TRUNK
	H	BUTTONBUSH *Cephalanthus occidentalis*	32	N/A	N/A	N/A	• 5 GAL.	
	I	BUSHY BLUESTEM *Andropogon glomeratus*	194	N/A	N/A	N/A	• 1 GAL.	
	J	SWITCHGRASS *Panicum virgatum*	224	N/A	N/A	N/A	• 1 GAL.	
	K	GRASS (See note below)	–					

* Size substitutions will be permitted based on availability

Grassing Note: Entire bioretention basin shall be grassed with Bamert Seed Company (www.bamertseed.com) "Deluxe Prairie Blend" seed at a rate of 20 lbs/acre. Prior to seed application the bioretention basin shall be mulched with shredded hardwood mulch 3 inches thick.

Rayzor Ranch, Denton

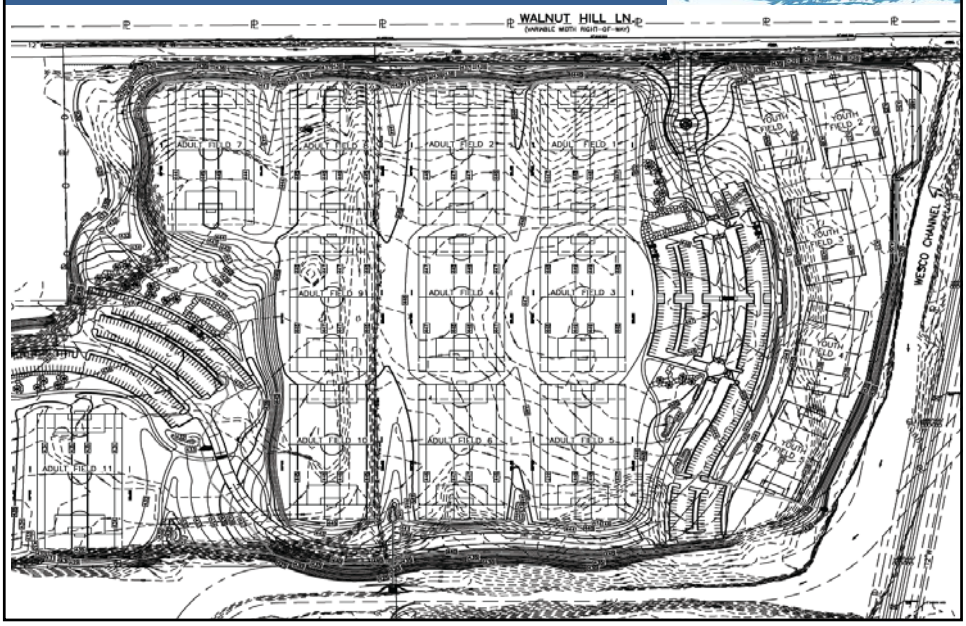
Denton, TX

Recently received a Section 319 Grant to proceed with a number of BMP projects

- Bioretention system at Denton Municipal Airport

Bioretention at Denton Municipal Airport

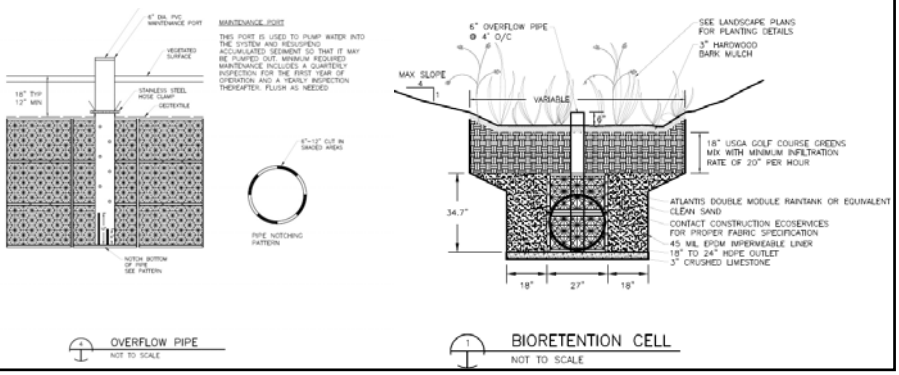
Elm Fork, Dallas



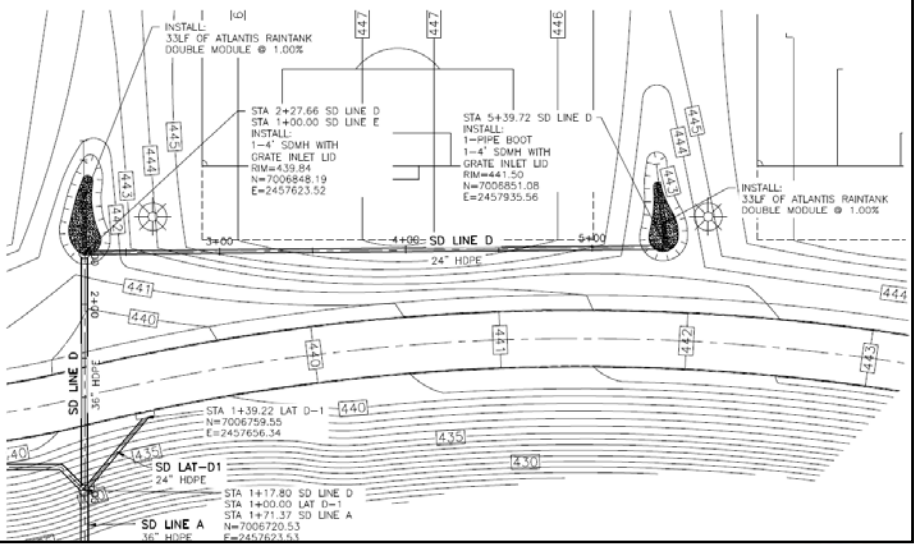
Elm Fork, Dallas

Water Quality Volume Calculations

	Area	% Impervious, I	Runoff Coeffecient, C	Volumetric Runoff Coefficient, Rv	Water Quality Volume, WQv	Filter Bed Depth (df)	Coefficient of Permeability, k	Average height of water above filter bed, hf	Design Filter Bed Drain Time, tf	Ponding Surface Area, Af
Area	ac	%	–	–	ft3	ft	ft/day	ft	days	ft2
3	1.58	0.70	0.80	0.0563	484.35	4.39	10.00	0.25	0.50	91.65
4	2.45	0.70	0.50	0.0563	751.06	4.39	10.00	0.25	0.50	142.12
6	2.66	0.50	0.50	0.0545	789.36	4.39	10.00	0.25	0.50	149.37
8	4.21	0.35	0.35	0.05315	1218.38	4.39	10.00	0.25	0.50	230.55
11	4.57	0.35	0.35	0.05315	1322.57	4.39	10.00	0.25	0.50	250.26
12	4.80	0.50	0.50	0.0545	1424.41	4.39	10.00	0.25	0.50	269.53
14	3.34	0.50	0.50	0.0545	991.15	4.39	10.00	0.25	0.50	187.55
16	4.13	0.50	0.40	0.0545	1225.59	4.39	10.00	0.25	0.50	231.91



Elm Fork, Dallas



Elm Fork, Dallas

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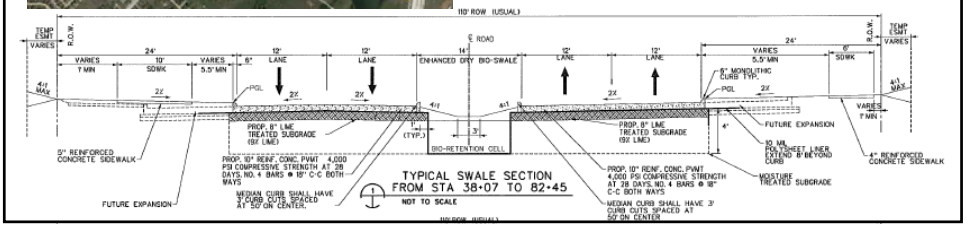
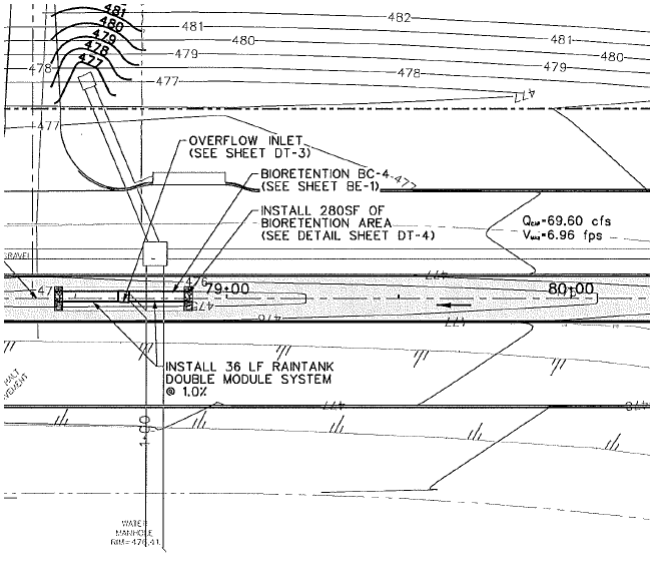
Merritt Road, Rowlett

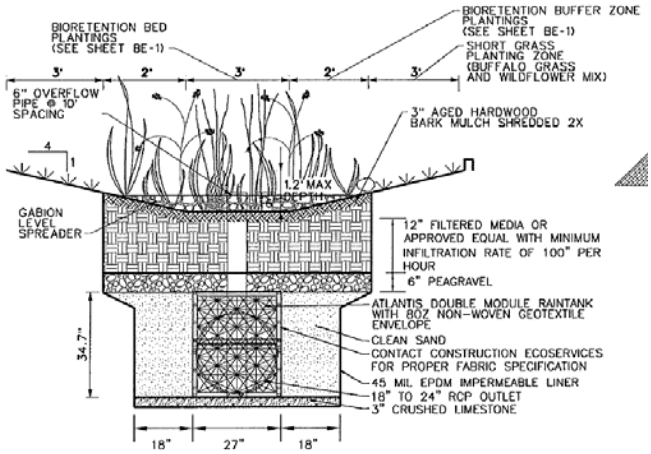
- Approx. 9,070 foot roadway project
- Approx. 3,600 feet of bioretention swales
- Between Liberty Grove Road and Pleasant Valley Road
- To be constructed Fall 2011 to Spring 2013



Merritt Road, Rowlett

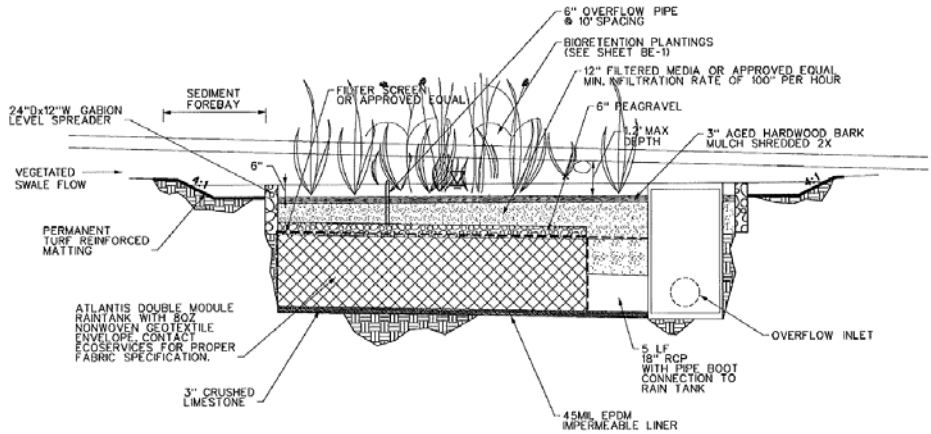


Merritt Road, Rowlett



1 BIORETENTION CELL
NOT TO SCALE

Merritt Road, Rowlett



5 BIORETENTION CELL PROFILE
NOT TO SCALE

References

- iSWM Technical Manual
  - Site Development Controls
  - Landscaping
- Bioretention Design Specifications and Criteria, Prince George's, Maryland, 2002
- City of Santa Barbara Stormwater BMP Guidance Manual, June 2008
- North Carolina Department of Environment and Natural Resources (NCDENR) Stormwater BMP Manual, July 2009
- Charlotte-Mecklenberg Stormwater Services, BMP Design Manual, July 2010

FREESE AND NICHOLS

North Central Texas Council of Governments

QUESTIONS?

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