Introduction to Design & Calculation Tools for LID

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Various BMPs for Low Impact Design:

Bioretention (Rain Garden)

Infiltration Trench

Grassed Swale

Infiltration Swale (Bio-swale)

Vegetative Filter Strip

Low Impact Design Tools:

TR-55 “Urban Hydrology for Small Watersheds”

Rain Garden (Bioretention) Spreadsheet

Infiltration Trench Spreadsheet

Vegetated Water Quality Swale and Enhanced WQ Swale (Bio Swale)

Vegetative Filter Strip Spreadsheet

Hydraulic Software (Pond Pack, HydroCad, Hydroflow, ICPR etc.)

“Site Evaluation Tool” S.E.T. (Developed by Tetra Tech)

Question:

What storm do we use for water quality control?

1 inch rainfall

1 year storm

2 year storm

10 year storm

All storms

Answer:

1 inch rainfall, sometimes called “First Flush”

Represents about 90% of annual storms and contains over 90% of pollutants in the runoff.

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

Conservation
Engineering
Division

Technical
Release 55

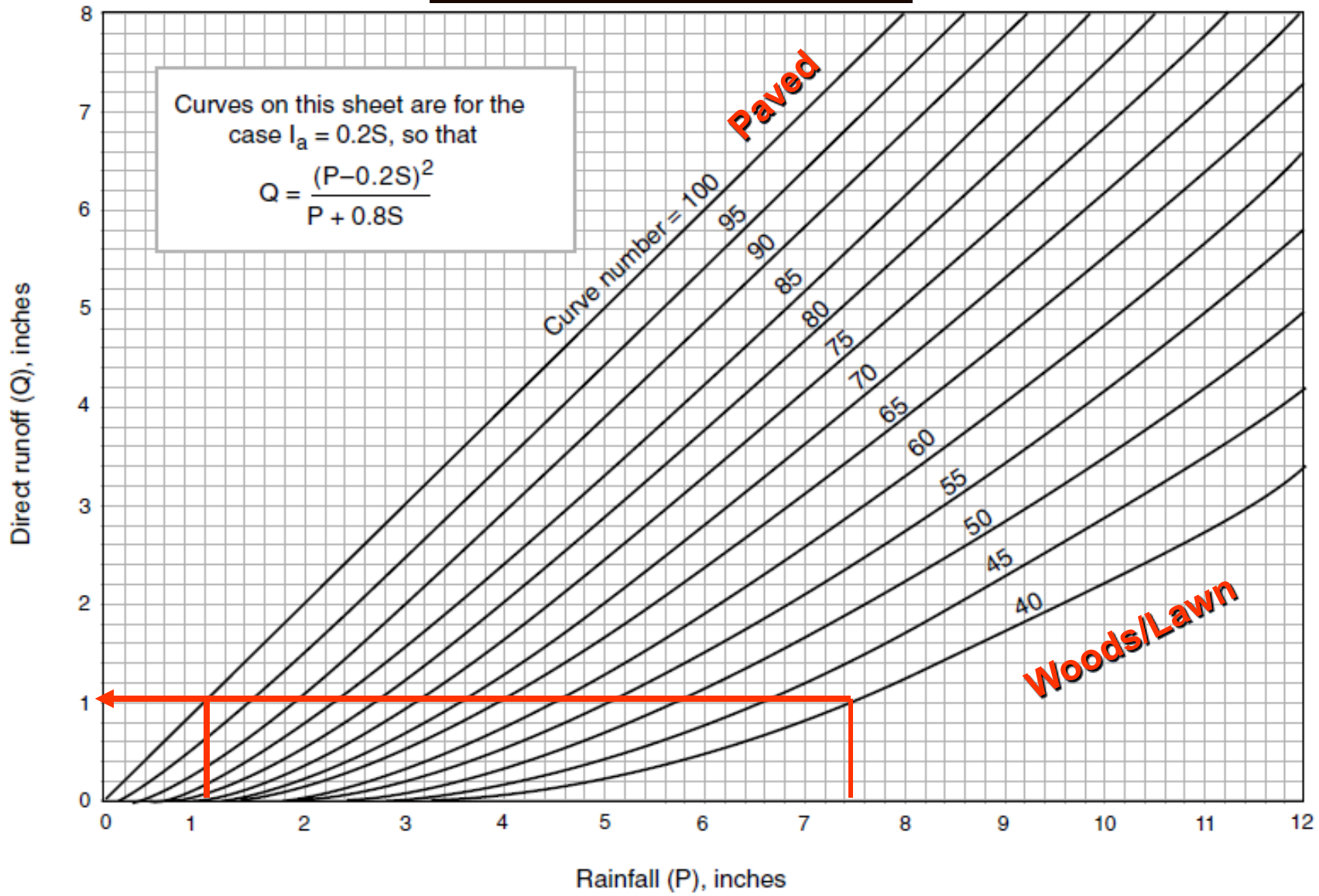
June 1986

Urban Hydrology for Small Watersheds

TR-55

Figure 2-1 Solution of runoff equation.

1" Rainfall or 1" Runoff ?



Water Quality Runoff:

WQv = (1.0RvA) / 12 (Schueler's "Simple Method")

Where WQv = water quality volume (acre-feet)

Rv = volumetric runoff coefficient

= 0.05 + 0.009 (I) , I = % Impervious

A = total drainage area (acres)

Example:

1 acre of parking lot with 1-inch rainfall

WQv = ((1.0 x (0.05 + 0.009 (100)) x 1 Ac) /12

= 3448 cubic feet of runoff

Question:

What duration storm do we use for our design?

1 inch instantaneously

1 inch in one hour

1 inch in 24 hours

1 inch in 6 hours

Since the mean storm duration for this area (Charlotte, NC) is about 6 hours, we chose that storm event.

This storm yields a peak of **1.71 cfs** per acre of impervious surface for Charlotte, NC.

Bioretention (Rain Gardens)

11/30/2007
Updated for 2007
NCDENR BMP Manual
as Amended

Rain Garden Sizing

Water Quality Volume WQv

Rv = runoff coefficient (Runoff/Rainfall)
Rv = 0.05 + 0.009(I)
Rv = Volumetric Runoff Coefficient (Runoff/Rainfall)
"I" = % Impervious
("Simple Method" - Schueler, 1987)
NCDENR Manual July 2007 pg. 3-3
Meck. Cty. BMP Manual pg. 3.2

Water Quality Protection Volume

$$WQv = \frac{1.0"RvA}{12}$$

Fill in Values:

"I" =	100	Percent	**Impervious of Site**
"A" =	1	Acres	5 Acre Maximum
Rv =	0.950		

Answer:

WQv =	0.079	Ac. Ft.
	3448	Ft.³
		FOR SHEET FLOW ENTRY:
	1.71	CFS Peak Flow for 1"- 6 Hr. Storm
	21	Length of Level Spreader for 1" @ 1 fps

SCS	
Method	3013
	CF

Compute CNm

Rv=	0.95	
WQv=	0.95	inches
CNm=	99.57	Use to compute Q_a

Rain Garden Area

Formula:

$$Af = \frac{(WQv)\,(Df)}{((k)\,(Hf+Df)\,(Tf))}$$

From Georgia Design Manual
Section 3.2.3.6
(Based on Darcy's Law)
Maryland Design Manual
Page 3.40

Where:

Af = Surface area of Rain Garden (S.F.)
WQv = Water Quality Volume to be Captured
Df = Filter Bed Depth (2 feet min. for grasses, 3 to 4 feet for trees)
k = permeability coefficient of filter media (use 1 Ft./Day for amended soil mix)
* See Maryland Stormwater Design Manual, Page 3.40
Hf = Average height of water above filter bed (Mulch)
(use 3 to 6 inches, which is one-half of 6" to 12" ponding depth)
Tf = Design filter bed drain time in days
* MAXIMUM 2 Days, (Use 1 Day)

Fill in Values:

"k" =	1	Ft./Day*
Df =	4	Feet
Hf =	6	inches
Tf =	1.425	Days*

Permeability Coefficients

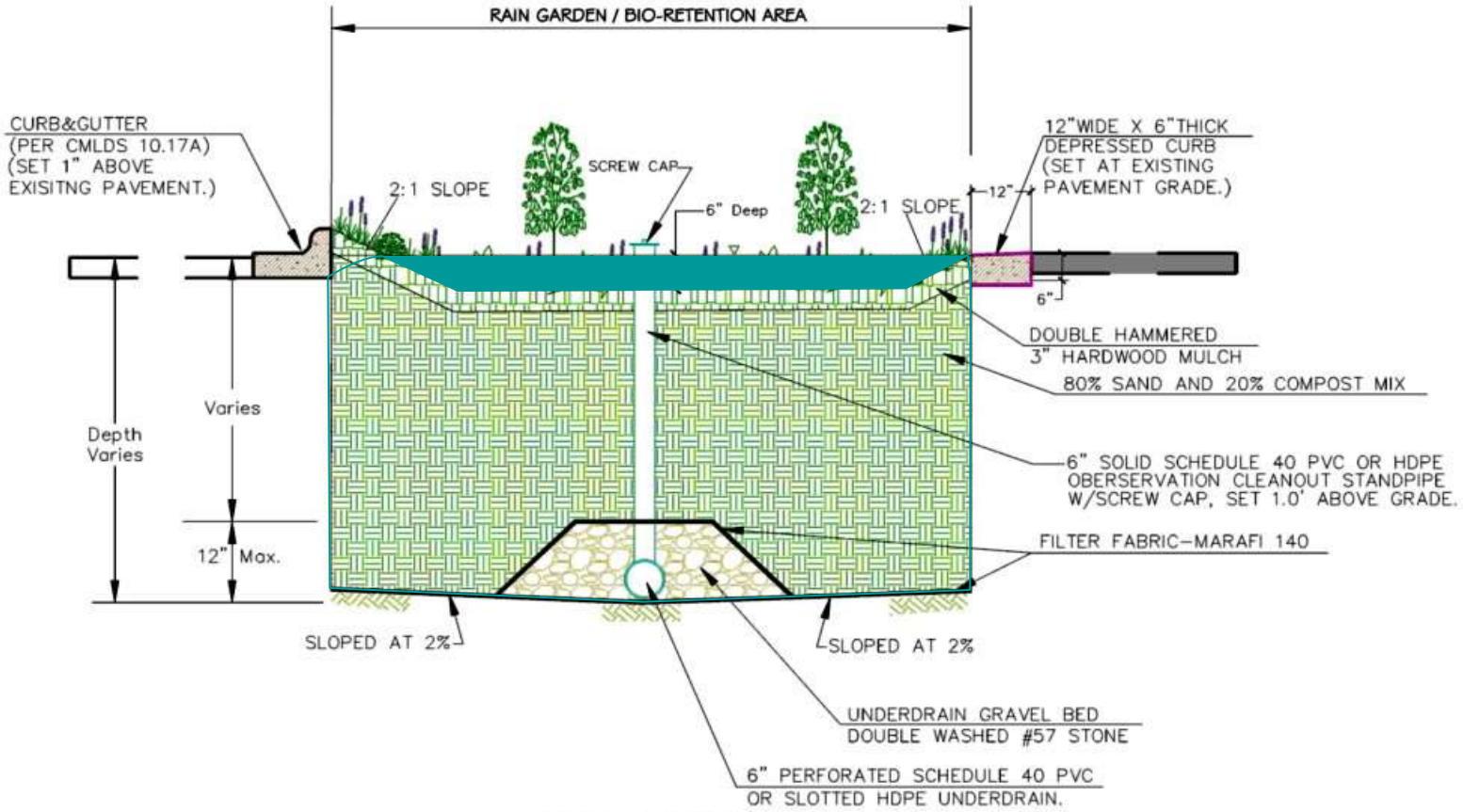
Soil Type	K (in./hr.)	K (Ft/Day)	
Sand	6	12	
Loamy Sand	2	4	
Sandy Loam	* 0.5 - 1	1 - 2	*Use 0.5 "/Hr, 1 Ft./Day
Silty Loam	0.02	0.05	

Required Size

Af =	2151	SF Required assuming infiltration during rainfall	
	3448	SF Req. by DENR Manual (Vol./Depth)	
	20.25	SF Impervious Per SF of Rain Garden	4.94 % of impervious site

Cost Estimate

Excavation		$2,415.14		
Stone Bedding		$250.33		
6" HDPE Pipe		$307.23		
6" Cleanout		$250.00		
Filter Fabric		$460.93		
Soil Mix		$4,033.17		
Mulch		$633.78		
Plants		$1,249.95		
	Cost	**$9,600.54**		
	Cost/SF	$9.26		
		$0.22	Cost / SF	Impervious



RAIN GARDEN

X-SECTIONAL VIEW

NOT TO SCALE

Infiltration Trench

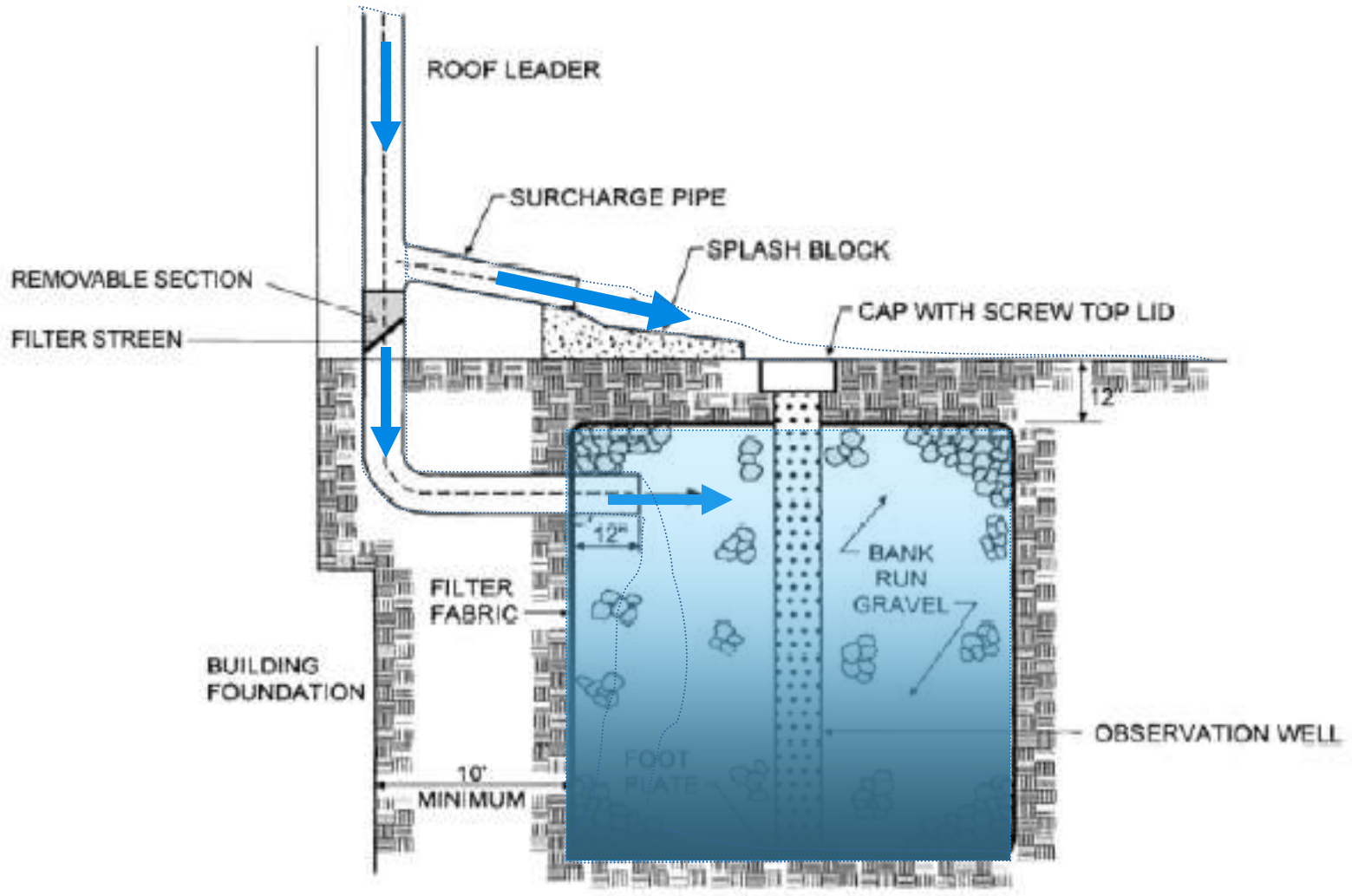


Figure 4: Infiltration Pit/Trench

Source: Adapted from Maryland Department of the Environment, 1998.

Infiltration Trench Design

Equation: $A = \frac{WQ}{(nd + kT/12)}$ From Georgia Stormwater Management Manual Section 3.2.5 for Stormwater Infiltration Practices

Where:
A = Surface Area Served
WQ = Water Quality Volume in Cubic Feet
n = porosity (Assume 0.32)
d = trench depth in feet
k = percolation rate in inches/hour (Assume 0.5"/Hr.)
T = Time to fill in hours

Length of Trench:

L = A/W Where W = allowable trench width

Fill in Values:

WQ =	3448	Water Quality Volume (CF) (See Below)
n =	0.32	Porosity #57 Stone
d =	4	Depth of Trench
k =	0.2	Percolation Rate of Soil (In./Hr.)
T =	2	Fill Time in Hours
W =	4	Allowable Trench Width

Answer:

A =	2626	Square Feet Required
L =	656	Length of Trench

WATER QUALITY VOLUME (WQv)

Rv = runoff coefficient (Runoff/Rainfall)
Rv = 0.05 + 0.009(I) Where "I" = % Impervious
("Simple Method" - Schueler, 1987)
NCDENR April 1999

$WQv = \frac{1.0"RvA}{12}$

Cost Estimate

Excavation		$5,831.00		
Stone Bedding		$16,036.00		
Filter Fabric		$1,750.00		
	Cost	**$23,617.00**		
	Cost/SF	**$8.99**		
		$0.54	Cost / SF	Impervious

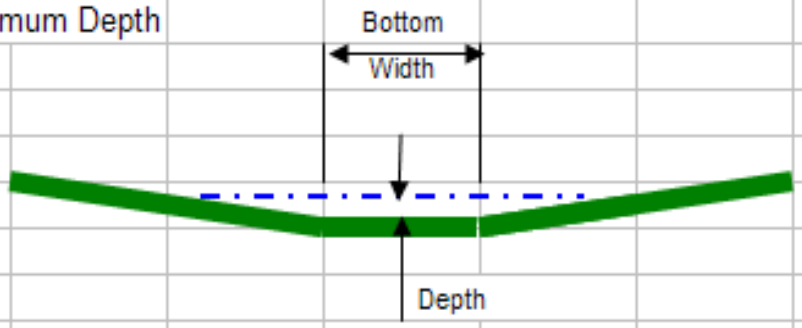
Grassed Swale

Design Considerations for Grassed Swale:

1. Keep velocities at or below 1 fps to allow settlement of solids.
2. Keep depth of flow below tip of grass for contact with suspended solids.
3. Use trapezoidal or parabolic shape for maximum capacity and low flow rate.
4. Keep side slopes at 3:1 or flatter for ease of mowing purposes.
5. Use trench drain at driveway crossing to minimize depth and ease of cleaning.

Grassed Trapezoidal Swale For Water Quality

BOTTOM WIDTH (FT)	4.00	**4.1**	Recommended Width
DEPTH (FT)	0.32	4 " Maximum Depth	
SIDE SLOPES (?H:1V) (FT)	3.0		
AREA (SQ. FT)	1.59		
WETTED PERIMETER (FT)	6.02		
HYDRAULIC RADIUS (FT)	0.26		
FLOW LENGTH (FT)	100.00		
ELEV UP (NGVD FT)	100.50		
ELEV DOWN (NGVD FT)	100.00		
CHANNEL SLOPE (FT/FT)	0.005	0.030 Recommended Maximum Slope	
MANNING'S "n"	0.040	n = 0.05 - 0.07 for Mowed Grass, Depth < 0.7 FT.	
AVERAGE VELOCITY (FT/SEC)	**1.1**	**Keep Below 1.5 fps**	
CAPACITY (Q, CFS)	**1.71**	This is the flow from 1" Rainfall - 6 hr. Duration	
TIME OF CONCENTRATION (HRS)	0.026	Try to provide **10 minutes** of contact time, at 1.5 fps = 900 feet of swale.	
Tc (MIN.)	1.5	at 1.0 fps = 600 feet of swale.	



Note: Keep swales wide and flat for mowing with adjacent lawns.
Keep depth of flow less than 4 inches for 1 inch rainfall.
Provide check dams, if necessary, to flatten slopes

Infiltration Swale (Enhanced, or Bio Swale)

5/7/2007

Enhanced Swale Sizing

Water Quality Volume WQv

Rv = runoff coefficient (Runoff/Rainfall)
Rv = 0.05 + 0.009(I) Where "I" = % Impervious
("Simple Method" - Schueler, 1987)
NCDENR April 1999

$$WQv = \frac{1.0"RvA}{12}$$

Fill in Values:

"I" =	100	Percent	Impervious of Site
"A" =	1	Acres	5 Acre Maximum

Answer:

WQv =	0.079	Ac. Ft.
	3448	Cubic Feet Required
	3104	Min. CF

Surface Area

Formula:

$$Af = \frac{(WQv)(Df)}{((k)(Hf+Df)(Tf))}$$

From Georgia Design Manual
Section 3.2.3.6
(Based on Darcy's Law)
Maryland Design Manual
Page 3.40

Where:

- Af = Surface area of Rain Garden (S.F.)
- WQv = Water Quality Volume to be Captured
- Df = Filter Bed Depth (2 feet min., 4 feet for trees)
- k = permeability coefficient of filter media (use 0.50 for amended soil mix)
  * See Maryland Stormwater Design Manual, Page 3.40
- Hf = Average height of water above filter bed
  (use 3 to 6 inches, which is one-half of 6" to 12" pond depth)
- Tf = Design filter bed drain time in days
  (1 Days or 24 hours)

Fill in Values:

"k" =	1	ft./day*
Df =	2	Feet
Hf =	1.5	inches
Tf =	1.435	Days*

Soil Type	K (in./hr.)	K (Ft/Day)
Sand	6	12
Loamy Sand	2	4
Sandy Loam	0.5 - 1	1 - 2
Silty Loam	0.02	0.05

Required Size

Af =	1533	SF Required
	6207	SF for 90% of WQv
Enter:	4	Width
	0.0125	Slope ft./ft.
	1552	Length
	40.0	Spacing of Check Dams 6" high

Water Draw Through Rate:

Darcy's Equation:

Q = (.0000232)*K*A*(H/L) — Q = 0.0444 cfs — Infiltration Rate

Where:

Q = Flow (Rate of Draw) through Bioretentioin Soil (cfs)

K = Hydraulic Conductivity of soil (in./hr.) (Usually 1"/Hour)

A = Surface Area of Bio-Retention Area (SF)

H = Height of Water above Drainage Pipe (Underdrain)

L = Thickness of Soil Bed (Usually 4')

Assume (H/L) ~ 1

Bottom Width	Storage Per 100 LF		SF Imperv. Treated	Acres
2.'	125 CF		1750	0.04
3.'	150 CF		2000	0.045
4.'	175 CF		2500	0.055
5.'	200CF		2850	0.065
6.'	225 CF		3150	0.075
7.'	250 CF		3500	0.08
8.'	275CF		3900	0.09

Time to Drawdown water from Inundation to Saturation at Surface:

Volume/Q: 17241 Seconds

4.8 Hours to Saturation

Note:

Treated areas Based on Scheuler's "Simple Formula"

Storage based on 0.5' check dams properly spaced.

Time to lower Water Table to 2.0 feet below surface:

Assume 40% Porosity

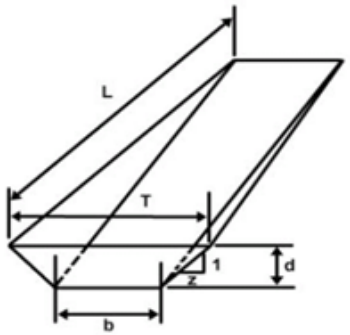
Volume = Area x 2' x 0.40

= 1226.1 Cubic Feet

= 27586 Seconds

= 7.7 Hours to Lower Water 2' below surface

12.5 Hours to Draw Water Through Soil Layer



Trapezoidal-Shaped Swale

Top width (T) = b + 2zd

Volume = $(d^2 zL)/3 + (dbL)/2$

Size Underdrains

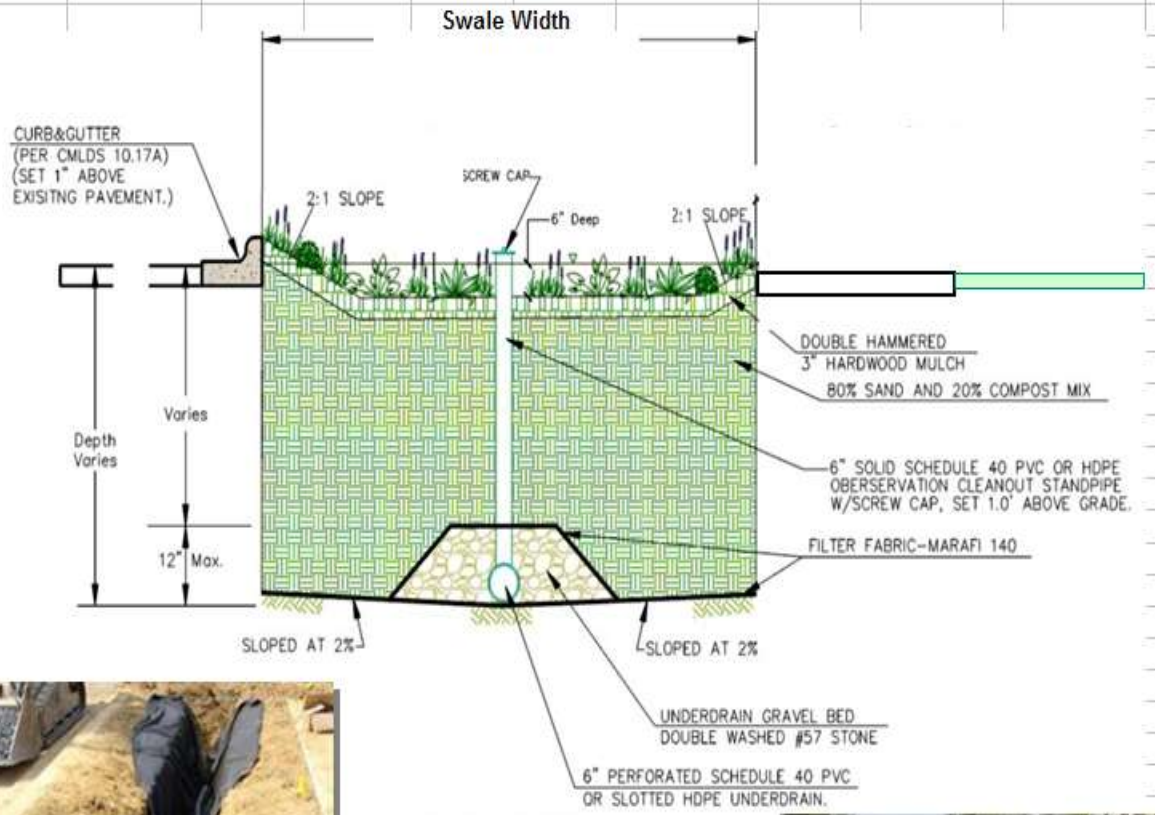
As a rule of thumb, the length of underdrain is based on 10% of Af

Source: (NY State Stormwater Manual)

L = 51 Feet in 3' wide stone bed

Required Diameter 6.6 Inches (Minimum 6 Inches)

Source: (NCSU Rain Garden Design Worksheet, Bill Hunt, PHD)



Cost Estimate

Excavation	$3,793.20
Stone Bedding	$4,741.50
6" HDPE Pipe	$5,431.17
6" Cleanouts	$3,879.41
Filter Fabric	$681.16
Soil Mix	$16,092.36
Sod	$1,556.26

Cost	$36,175.05		
Cost/SF	$5.83		
	$0.83	Cost / SF	Impervious


Vegetated Filter Strip

Water Quality Vegetated Filter Strip

Manning's Equation:

$q_w = \frac{1.49 \times d_f}{n} (R^{2/3} \times S^{0.50})$

Source: SCDHEC - OCRM

"Post Development BMP Design Aid Manual"

Pages 69 - 70

n = 0.40 Light Underbrush

$R = d_f * S_s / S_s + 2d_f$

Ss = spacing of grass media

S_s = 0.67 inches, 0.0558Feet

$q_w = d_f V$ $V = q_w / d_f$

Where q_w = Flow Rate per Foot of Width

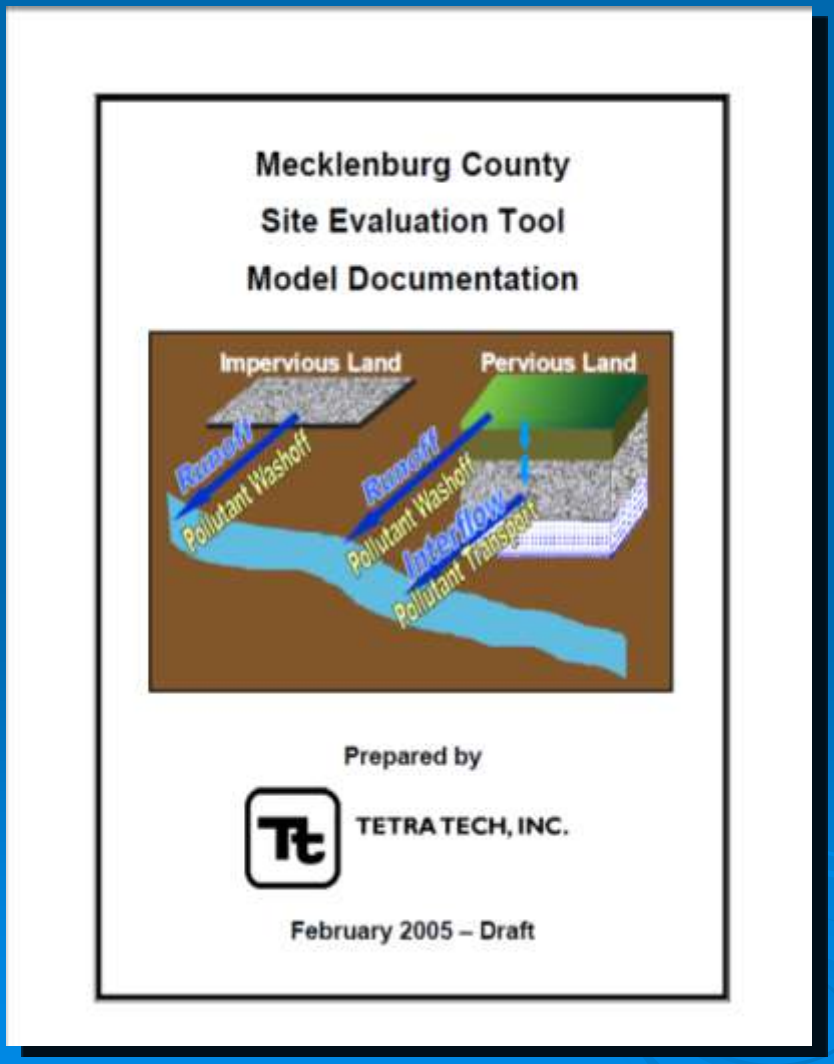
d_f = Flow Depth in Feet

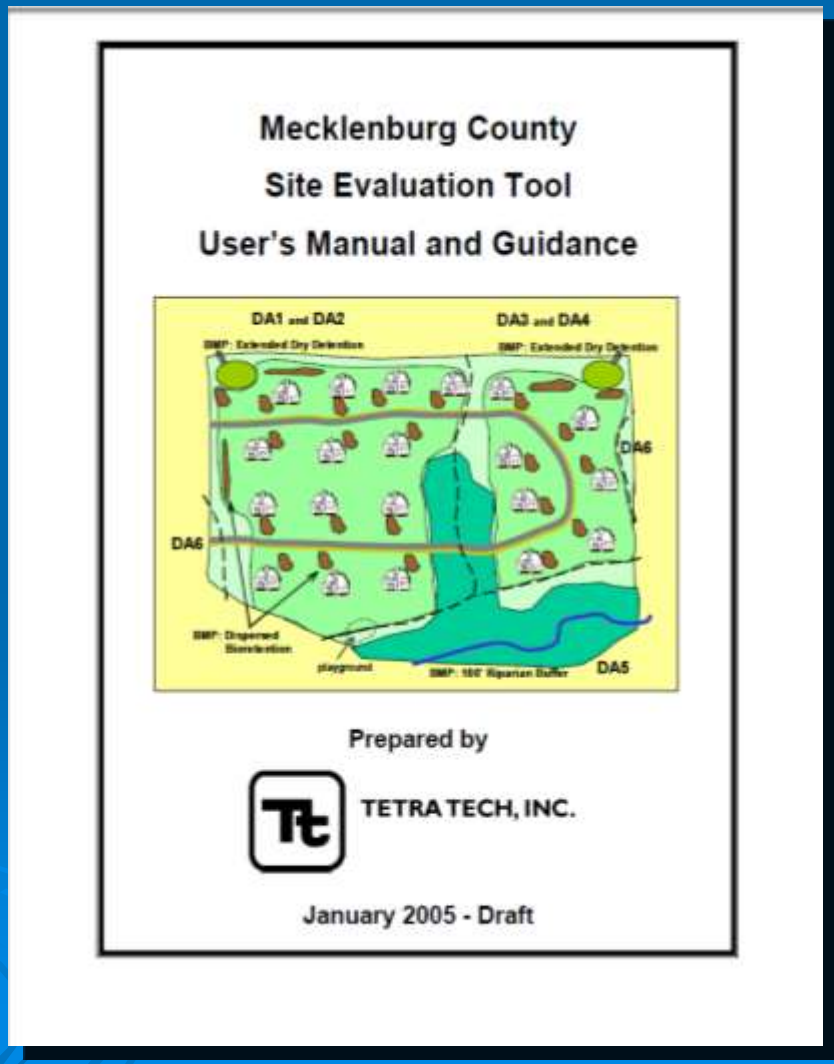
Input Data:

Q=	1.71	CFS	From 1 inch Rainfall (6 Hr. Duration)
d_f =	0.08	Ft.	Use 1" Depth (0.08 Ft.)
Slope =	0.02	Ft./Ft.	Min. 0.02, Max. 0.10 Ft./Ft.
n =	0.4		See Table
q_w=	0.008	CFS/Ft.	
V =	0.10	fps	
L =	38	Ft. of Slope	Min. 50 Ft.
Tt =	6.3	Minutes of contact	
Min. Width =	204	Ft. of Level Spreader	Max. 300 Ft.

Values of "n" for Various Vegetated Surfaces		
	Sheet Flow < 1" Depth	
Lawn	0.24	
Woods	0.40	Light Underbrush
	0.60	Heavy Underbrush

Site Evaluation Tool
S.E.T.





General Site Information

Click to proceed to Land Use

General Site Information

Project Information	
Company/Org:	Mecklenburg County
Project:	Forest Lake Estates
Jurisdiction:	Huntersville
Scenario:	Single Family Subdivision

Site Information	
Area (acres)	36.720
Average Site Slope (%) (Enter value or select from range)	(enter) < 2% 2% - 6% > 6%

Soil Hydrologic Groups (% of Site Area)	
Group A	
Group B	100.00%
Group C	
Group D	

Totals OK

Design Storm Selection

Runoff Volume (storm event)
☑ 1 inch storm
☑ 1-year 24-hour
☑ 2-year 24-hour

Pollutant Target Selection

Percent Reduction of Load*	
☑ Total Phosphorus	70% (enter)
☑ Total Nitrogen	45% (enter)

* Targets addess surface runoff load from developed portion of site.

Septic Information

Number of Homes on Septic	0
Commercial Systems (gal/yr)	0

Land Uses

Click to proceed to DAs

Land Use Entry	Existing Land Use		Proposed Land Use	
	Area (ft^2)	% of Site	Area (ft^2)	% of Site
Pervious Areas				
Row Crops		0.0%		0.0%
Pasture		0.0%		0.0%
Forest	1,599,523	100.0%	435,773	27.2%
Wetland		0.0%		0.0%
Meadow		0.0%		0.0%
Lawn		0.0%	635,500	39.7%
Impervious Areas				
Residential & Light Industrial				
Rooftops		0.0%	218,000	13.6%
Driveways & Parking Lots		0.0%	70,850	4.4%
Other Impervious Area		0.0%	32,700	2.0%
Road		0.0%	153,700	9.6%
Sidewalk		0.0%	53,000	3.3%
Commercial & Heavy Industrial				
Rooftops		0.0%		0.0%
Parking Lots		0.0%		0.0%
Other Impervious Area		0.0%		0.0%
Road		0.0%		0.0%
Sidewalk		0.0%		0.0%
Storm Water Management Facilities				
Pond/Wetland Surface Area		0.0%		0.0%
Permeable Pavement		0.0%		0.0%
Green Roof		0.0%		0.0%
All Other BMPs (except Forested Buffer)		0.0%		0.0%
Site Totals:	1,599,523	100.0%	1,599,523	100.0%
Check Land Use Totals:	Equals Site Area		Equals Site Area	
Total Site Impervious Cover	0.00%		33.03%	

Drainage Area Breakdown

Required Entry Complete

Drainage Areas (DA) associated with BMP sets

Proposed Land Use Data by DA	Project Areas (ft^2)	Unassigned Area (ft^2)	Enter drainage area names in next row if desired									
			DA1	DA2	DA3	DA4	DA5	DA6	DA7	DA8	DA9	DA10
Pervious Areas												
Row Crops	0	0										
Pasture	0	0										
Forest	435,773	0	253,773	82,000	100,000							
Wetland	0	0										
Meadow	0	0										
Lawn	635,500	0	466,900	84,100	84,500							
Impervious Areas												
Residential & Light Industrial												
Rooftops	218,000	0	218,000									
Driveways & Parking Lots	70,850	0	70,850									
Other Impervious Area	32,700	0	32,700									
Road	153,700	0	153,700									
Sidewalk	53,000	0	53,000									
Commercial & Heavy Industrial												
Rooftops	0	0										
Parking Lots	0	0										
Other Impervious Area	0	0										
Road	0	0										
Sidewalk	0	0										
Storm Water Management Facilities												
Pond/Wetland Surface Area	0	0										
Permeable Pavement	0	0										
Green Roof	0	0										
All Other BMPs	0	0										
Total Area	1,599,523	0	1,248,923	166,100	184,500							

Proposed Drainage Area (DA) assignments match Proposed Land Use.

Proposed BMPs

Proceed to Model Output | Cost Tool

Select BMPs for Drainage Areas defined on DAs sheet

BMP Assignment for each DA	DA1	DA2	DA3	---	---	---	---	---	---	---
Conventional Dry Detention	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Extended Dry Detention	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wet Pond	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Stormwater Wetland	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Bioretention	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sand Filter (DE Design)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Infiltration Trench	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Grass Swale	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
WQ Swale (MD Design)	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐
Veg FS w/ Level Spreader	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
User-defined BMP	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forested Buffer	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐
Width of protected forest buffer in each DA (ft):		140	140							
Percent of DA within treatment zone:		100.0%	100.0%							
Green Roof	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Permeable Pavement	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

Grass Swales cannot be used in combination with Maryland Dry Swale.

Net Reductions (single or multiple BMPs)	DA1	DA2	DA3	---	---	---	---	---	---	---
Annual Runoff converted to infiltration	16.3%	5.0%	5.0%	--	--	--	--	--	--	--
Total Nitrogen	75.3%	36.1%	36.1%	--	--	--	--	--	--	--
Total Phosphorus	88.3%	45.0%	45.0%	--	--	--	--	--	--	--
TSS	98.4%	69.4%	69.4%	--	--	--	--	--	--	--
Fecal Coliform	97.9%	5.0%	5.0%	--	--	--	--	--	--	--

BMP Storage & Storm Data

Optional BMP Storage Volume and Overall Site Peak Flow

Enter *extended detention storage volume** for each selected BMP
(Sum storage volumes across the entire site for each BMP type)

	Storage (ft^3)
BMP Class	User-Entry
Extended Dry Detention	100,188
Wet Pond	
Stormwater Wetland	
Bioretention	34,777
Sand Filter (DE Design)	
Infiltration Trench	
WQ Swale (MD Design)	
Green Roof	
Permeable Pavement	
User-defined BMP	

Enter post-BMP Overall Site Peak Flow (cfs)

Storm Event	Peak
2-yr 24-hr storm (cfs)	5.2
10-yr 24-hr storm (cfs)	

Specify Time of Concentration (in minutes) if known

	Existing Land Use	Proposed Land Use
2-yr 24-hr storm (min)	44	22
10-yr 24-hr storm (min)		

* Extended detention storage volume is the volume stored for water quality purposes (generally 24 to 48 hours minimum). It does NOT include the permanent pool for ponding BMPs.

User Defined BMPs

MeckCo-SET 3.3 Dec2005

Use this page to enter information for a user-defined BMP.

Enter BMP name, established removal rates for targeted pollutants, and hydrologic impacts. Brief description and references to scientific documentation supporting assigned removal efficiencies MUST be included.

Example		
	BMP Name:	Organic Sand Filter
Infiltration	Annual flow converted to infiltration (percent)	0%
ET*	Annual flow converted to evaporation (percent)	3%
Removal Efficiencies (as percent)	Total N	35%
	Total P	40%
	TSS	65%
	Fecal Coliform	0%

* ET = evapotranspiration (combination of evaporation and plant transpiration)

Example Documentation
Organic Sand Filters are similar to surface sand filters except they use compost or peat/sand as the filter media. The treated water filters through the media and is collected through perforated pipes in an underlying gravel bed. The runoff is directed to an outlet. A impermeable liner prevents movement of the treated water into groundwater. Source: Claytor, R.A. and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Ellicott City, MD.

No User BMPs selected on BMPs sheet, no user input required.

Site Data | Land Use | DAs | BMPs | **User BMP** | Model Output | BMP Cost | Other Cost | Adjust Cost | Cost

Model Output

Mecklenburg County Site Evaluation Tool - Site Performance Analysis

Forest Lake Estates
Huntersville
Single Family Subdivision

Land Use Summary

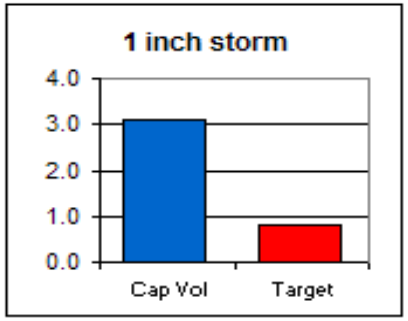
Total Site Area (acres)	36.72
Pre-development impervious percentage	0.0%
Post-development impervious percentage	33.0%

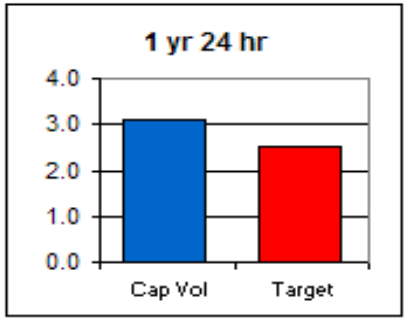
Annual Hydrology Summary

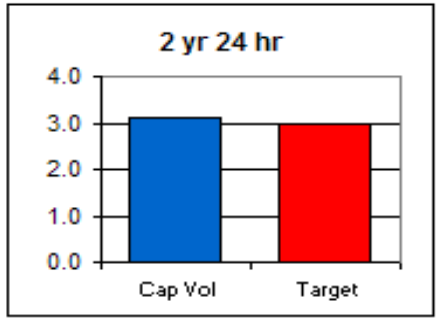
	Existing Landuse	Design without BMPs	Design with BMPs
Annual Surface Runoff (inches/yr)	2.68	14.01	5.31
Annual Infiltration (inches/yr)	12.00	7.08	9.30

Storm Event Runoff Volume and Target Summary

Runoff Volume (ac-ft)	Existing Landuse	Design without BMPs	BMP Storage Volume	Target	Meets Goal?
1 inch storm	0.000	0.802	3.098	0.802	Yes
1-yr 24-hr storm	0.601	3.096	3.098	2.495	Yes
2-yr 24-hr storm	1.156	4.127	3.098	2.971	Yes

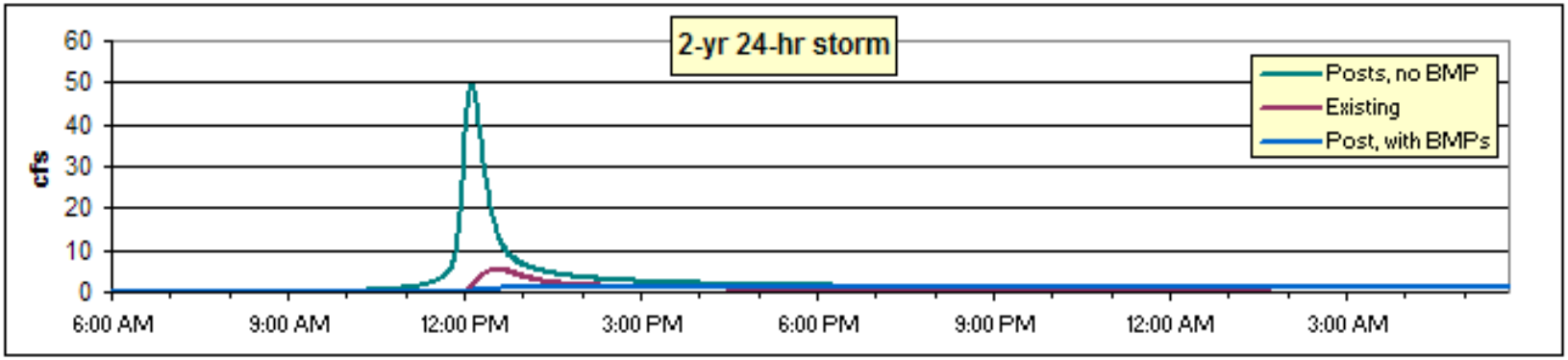


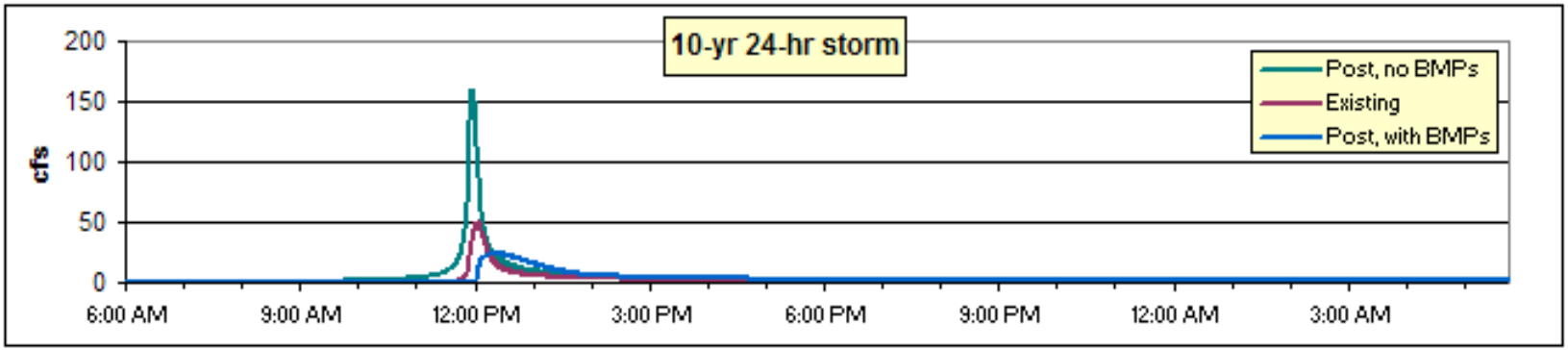




Peak Flow and Hydrograph Summary

	Existing Landuse	Design without BMPs	Design with BMPs	Source	Target	Meets Goal?
2-yr 24-hr storm (cfs)	5.38	49.44	5.20	User-defined	5.38	Yes
10-yr 24-hr storm (cfs)	50.24	159.24	24.22	Estimated	50.24	Yes

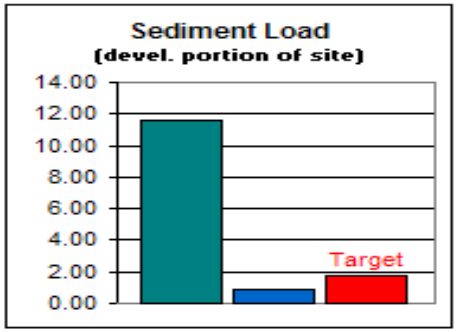


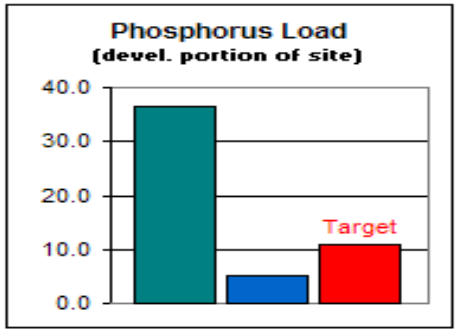


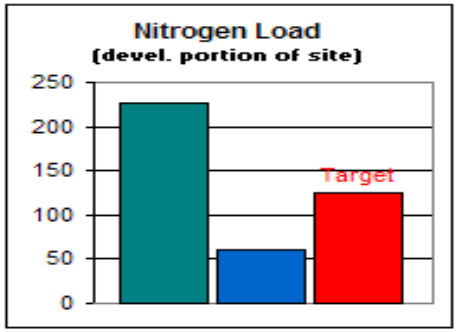
Annual Pollutant Load and Target Summary

Target Evaluation
(developed portion of site)

	Sediment (ton/yr)	Total Phosphorus (lb/yr)	Total Nitrogen (lb/yr)
Design without BMPs	11.65	36.4	227
Design with BMPs	0.92	5.3	61
Target Removal	85.0%	70.0%	45.0%
Achieved Removal	92.1%	85.5%	73.1%
Meets Goal?	Yes	Yes	Yes
Additional load from undeveloped areas removed by BMPs	1.31	1.1	5

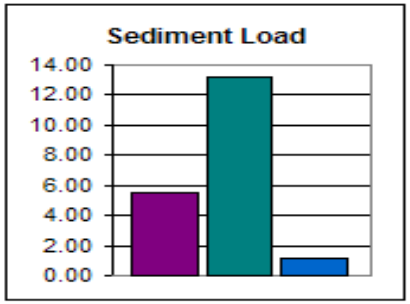


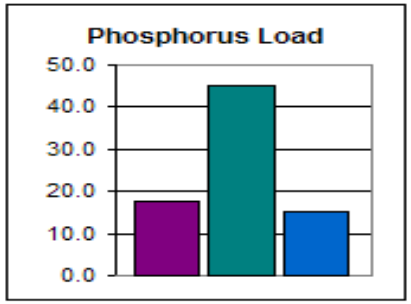


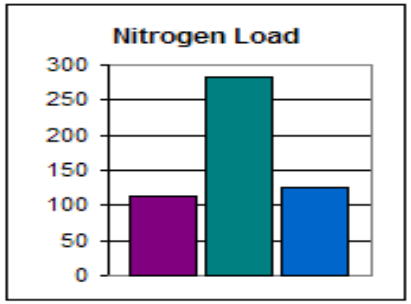


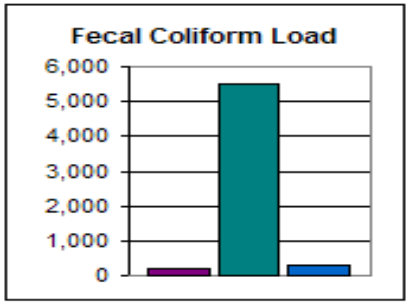
Entire Site Annual Load

	Sediment (ton/yr)	Total Phosphorus (lb/yr)	Total Nitrogen (lb/yr)	Fecal Coliform (# x 10^9/yr)
Existing Landuse	5.57	17.5	112	208
Design without BMPs	13.16	45.0	282	5,485
Design with BMPs	1.13	15.0	127	293









Any Questions ?

Site Evaluation Tool
http://www.charmeck.org/Departments/StormWater/Contractors/Huntersville+LID.htm