City of Rocky Mount, North Carolina
Stormwater Design Manual

Appendices

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One Government Plaza
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APPENDIX A: ACRONYMS AND DEFINITIONS

Bioretention - An engineered means of managing stormwater runoff, using chemical, biological and physical processes via a natural, terrestrial-based community of plants, microbes and soil. Bioretention provides two important functions: (1) water quantity (flood) controls; and (2) improves water quality through removal of pollutants and nutrients associated with runoff.

Catch Basin - A structure located within a curb and gutter section that allows water to enter into the storm drainage system. The catch basin has an opening in the curb and may or may not have an opening in the gutter section covered by a grate.

Design Storm - A theoretical storm of a given frequency that will produce a simulated runoff peak and volume having the same return frequency. Thus, a 100-year design storm should produce a 100-yr runoff and volume.

Drop Inlet - A vertical inlet to a buried culvert or storm drainage pipe with a flat grate inlet.

DWQ – North Carolina Division of Water Quality.

Easement - A right to use the land of another for a specific purpose, such as for a right-of-way or utilities.

Forebay - Excavated settling basin or a section separated by a low weir at the head of the primary impoundment. The forebay serves as a repository for a large portion of sediment and facilitates draining and excavating the basin.

Grass Swales - A series of vegetated, open channels that are designed to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows through the channels, it is treated through filtering by vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils.

Grate Inlet - Depressions or cavities in the pavement or ground that are covered by a steel grate and designed to collect and covey stormwater. Grate inlets can be found in parking lots, roadway medians and along town streets.

Illicit Connection - Any discharge to a municipal separate storm sewer that is not composed entirely of stormwater (some discharges may be authorized by an NPDES permit) and discharges resulting from fire fighting activities.

Impervious Surface - Surfaces providing negligible infiltration such as pavement, buildings, recreation facilities(e.g. tennis courts, etc.), and covered driveways. This will include porous pavement, gravel roads, parking areas and precast concrete, but does not include wooden slatted decks or the water surface area of swimming pools.

Junction Box – Where stormwater drain lines join or intersect, a box installed to accommodate changes in flow direction, pipe diameter and elevation.

Level Spreader - A device used to spread out stormwater runoff uniformly over the ground surface as sheetflow (i.e., not through channels). The purpose of a level spreader is to prevent concentrated, erosive flows from occurring and to enhance infiltration.

NCDENR – North Carolina Department of Environment and Natural Resources.

New development - shall be defined as to include the following: 1) any activity that disturbs greater than one acre of land in order to establish, expand or modify a single family or duplex residential development or a recreational facility; 2) any activity that disturbs greater than one-half an acre of land in order to establish, expand or modify a multifamily residential development or a commercial, industrial or institutional facility; and 3) does NOT include agriculture, mining or forestry activities. Land disturbance is defined as grubbing, stump removal and/or grading.

NPDES – National Pollutant Discharge Elimination System.

Open Channel - A long, narrow, open trench dug into the ground usually at the side of a road or field, which is used especially for supplying or removing water, or for dividing land.

Plug Flow - Fluid particles pass through the basin and are discharged in the same sequence in which they enter. The particles remain in the system €or a time equal to the theoretical detention time. This type of flow is especially appropriate for basins with high length-to-width ratios (Metcalf and Eddy, Inc., 1979).

Record Drawings - The primary outlet is often constructed of a rised barrel assembly and

Principal Spillway - The primary outlet is often constructed of a rised barrel assembly and provides flood protection (ie. for the 10-yr. storm) or reduces the frequency of the operation of the emergency spillway.

Riparian Buffer - an area of trees, usually accompanied by shrubs and other vegetation, that is adjacent to a body of water and which is managed to maintain the integrity of stream channels and shorelines, to reduce the impact of upland sources of pollution by trapping, filtering, and converting sediments, nutrients, and other chemicals, and to supply food, cover, and thermal protection to fish and other wildlife.

Spillway - A sluiceway or passage for excess water in a reservoir, to prevent too much pressure on the dam.

Storm Drainage System – Natural or man-made individual structures, designed in combination, with the express purpose of conveying stormwater to larger water bodies.

Storm Event - A rainfall event that produces more than 0.1 inch of precipitation and is separated from the previous storm event by at least 72 hours of dry weather.

Stormwater Wetlands - Manmade structure that is regularly saturated by surface or groundwater and subsequently characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions.

Travel Lane - A strip of roadway intended to accommodate the forward movement of a single line of vehicles. A solid or broken line is used to separate individual traffic lanes from each other and from the shoulder of the road.

Vegetated Filter Strips - Strips of vegetation separating a water body from a land use that could act as a non-point pollution source. Vegetated buffers are variable in width and can range in function from vegetated filter strips to wetlands or riparian areas.

Wet Detention Pond – Detention basins are excavated areas or natural depressions designed to detain stormwater runoff. These structures detain or impede flow by storing runoff and releasing the stored volume at a reduced rate.

APPENDIX B: DESIGN FORMS AND CHECKLISTS

Design Checklist: Wet Detention Pond

Project: ______________________________

Form Completed By: ______________ Date: ______________

Form Checked By: ______________ Date: ______________

PRELIMINARY HYDROLOGIC CALCULATIONS

1. Water Quality Volume		
Runoff Coefficient, R_v	R_v = ________	
WQv	WQ_v = ________	acre-ft
Average release rate over 48-hour period	Rate = ________	cfs
2. 1-Year Detention Requirements		
Existing Condition 1-year discharge	1-year = ________	cfs
3. Flood Detention Requirements		
Existing Condition 10-year discharge	10-year = ________	cfs
Existing Condition 25-year discharge	25-year = ________	cfs

POND DESIGN

1. Surface Area of Normal Pool		
Drainage Area	DA = ________	acre(s)
Percent Impervious	Impervious = ________	%
Depth	Depth = ________	ft
Surface Area of Normal Pool	SA = ________	acre
2 Sediment Forebay		
Volume	Vol_{pre} = ________	cu. ft.
3. Pond Design Characteristics		
Normal Pool Elevation	Elevation = ________	ft
Normal Pool Volume	Volume = ________	cu. ft.
Top of Embankment	Top = ________	ft
WQv Elevation	WQv Elev. = ________	ft
WQv Volume	WQv Vol. = ________	cu. ft.
1-year peak elevation	________	ft
1-year outlet discharge	________	cfs
10-year peak elevation	________	ft
10-year outlet discharge	________	cfs
25-year peak elevation	________	ft
25-year outlet discharge	________	cfs
100-year peak elevation	________	ft
100-year outlet discharge	________	cfs
4. Elevation-Discharge Rating Curve	Separate Sheet	
5. Elevation-Storage Rating Curve	Separate Sheet	
6. Hydrograph Routing	Separate Sheet	

Notes: ______________________________

Design Checklist: Stormwater Wetland

Project: ____________________

Form Completed By: ____________ Date: ____________

Form Checked By: ____________ Date: ____________

PRELIMINARY HYDROLOGIC CALCULATIONS

1 Surface Area Required for Wetland

% imperviousness of drainage area	% = ______
Drainage Area	DA = ______ acres
SA/DA from Table	SA/DA = ______
Surface Area Required for Wetland	SA = ______ sq. ft.

2. Water Quality Volume

Runoff Coefficient, R_v	R_v = ______
WQv	WQ_v = ______ acre-ft
Average Release Rate Over 48-hour Period	Rate = ______ cfs

3. 1-Year Detention Requirements

Existing Condition 1-year discharge	1-year = ______ cfs

4. Flood Detention Requirements

Existing Condition 10-year discharge	10-year = ______ cfs
Existing Condition 25-year discharge	25-year = ______ cfs

STORMWATER WETLAND DESIGN

1. Wetland Design

Micropool Area	$Area_{mp}$ = ______ sq. ft.,	% = ______
Sediment Forebay Area	$Area_{mp}$ = ______ sq. ft.,	% = ______
Pool/Deepwater Wetland Zone (1.5 - 6 feet deep)	$Area_{dw}$ = ______ sq. ft.,	% = ______
Low Marsh Wetland Zone (6-12 inches deep)	$Area_{low}$ = ______ sq. ft.,	% = ______
High Marsh Wetland Zone (0-6 inches deep)	$Area_{high}$ = ______ sq. ft,	% = ______
	Σ =	100.00%

2. Sediment Forebay

Volume	Vol_{pre} = ______ cu. ft.
Drainage Area	DA = ______ acres
Impervious Area	Imperv. = ______ acres

3. Wetland Final Design Characteristics

Normal Pool Elevation	______ ft
Top of Embankment	______ ft
WQv Elevation	______ ft
WQv Volume	______ cu. ft.
1-year peak elevation	______ ft
1-year outlet discharge	______ cfs
10-year peak elevation	______ ft
10-year outlet discharge	______ cfs
25-year peak elevation	______ ft
25-year outlet discharge	______ cfs
100-year peak elevation	______ ft
100-year outlet discharge	______ cfs

4. Elevation-Discharge Rating Curve — Separate Sheet

5. Elevation-Storage Rating Curve — Separate Sheet

6. Hydrograph Routing — Separate Sheet

Notes: ____________________

Design Checklist: Riparian Buffer

Project: ______________________________

Form Completed By: ______________ Date: ______________

Form Checked By: ______________ Date: ______________

1. Computed WQv	
WQ_v	WQ_v = ________ acre-ft
Q_p	Q_p = ________ cfs
2. Drainage Area	A = ________ acre(s)
3. Diversion structure	
Low Flow Orifice - Orifice Equation	A = ________ ft^2
Orifice Diameter	D = ________ in
4 Level Spreader	________
Entrance Width	Enter W = ________ ft
End Width	Exit W = ________ ft
Depth	Depth = ________ ft

Notes: ______________________________

Design Checklist: Grassed Swales

Project: ____________________

Form Completed By: ____________________ Date: ____________________

Form Checked By: ____________________ Date: ____________________

1. Computed WQv	WQ_v = ______ acre-ft
2. Drainage Area	A = ______ acre(s)
	______
3. Peak Runoff	
Peak Runoff, 10-year event	Q_{p-10} = ______ acre-ft
Velocity, 10-year event	V_{p-10} = ______ ft/s
4. Swale Dimensions	
Length	Length = ______ ft
Width	Width = ______ ft
Longitudinal Slope	S = ______ ft/ft
Side Slopes	Side Slopes = ______ (h:v)

Notes: ____________________

Design Checklist: Water Quality Swale

Project: ______________________________

Form Completed By: ______________ Date: ______________

Form Checked By: ______________ Date: ______________

1. Computed WQv	
WQv	WQ_v = ________ acre-ft
2. Computed $Q_{p\text{-}10}$	
$Q_{p\text{-}10}$	$Q_{p\text{-}10}$ = ________ acre-ft
$V_{p\text{-}10}$	$V_{p\text{-}10}$ = ________ ft/s
3. Sediment Forebay Volume	
Volume	Vol_{pre} = ________ acre-ft
4. Swale Dimensions	
Length	Length = ________ ft
Width	Width = ________ ft
Side Slopes	Side Slopes = ________ (h:v)
Area	Area = ________ ft^2
Longitudinal Slope	S = ________ ft/ft
5. Check Dams	
Depth	Depth = ________ ft
Spacing Distance	Distance = ________ ft
Number of Check Dams	No. = ________
6. Filter	
Area	A_F = ________ ft^2
Depth	Depth = ________ in
Draw Down Time	Time = ________ hr
Permeability	Fc = ________ in/hr

Notes: ______________________________

Design Checklist: Vegetated Filter Strip With Level Spreader

Project: ______________________

Form Completed By: ____________ Date: ____________

Form Checked By: ____________ Date: ____________

1. Computed WQv	
WQ_v	WQ_v = ________ acre-ft
Q_p	Q_p = ________ cfs
2. Drainage Area	
Area	A = ________ acre(s)
3. Diversion structure	
Low Flow Orifice - Orifice Equation	A = ________ ft^2
Orifice Diameter	diam. = ________ in
4. Filter Strip	
Length	L_f = ________ ft
Width	W = ________ ft
Slope	S = ________ ft/ft
Level Spreader Width	W_f = ________ ft
5. Level Spreader	
Length	L = ________ ft
Depth	D = ________ ft

Notes: ______________________

Design Checklist: Bioretention (Rain Gardens)

Project: ____________________

Form Completed By: ____________ Date: ____________

Form Checked By: ____________ Date: ____________

BIORETENTION DESIGN

1. Compute WQ_v volume requirements	WQ_v = ________ acre-ft
2. Drainage Area	A = ________ acre
3. Bioretention Filter	A_f = ________ ft^2
Filter Depth	Depth = ________ in
Filter Length	Length = ________ ft
Filter Width	Width = ________ ft
4. Engineered Soil	
Depth of Soil	Depth = ________ in
Clay Content	Clay = ________ %
Infiltration Rate	Rate = ________ in/hr
pH	pH = ________
Organic Content (%)	Organics = ________ %
Soluble Salts	Salts = ________ ppm
Phosphorus Index	P = ________
5 Conveyance to Bioretention Facility	online or offline (circle one)
6 Depth of Pond for _____-year Event	
Ponding Depth Above Filter	Depth = ________ in
Design Year Event	Design = ________ - year event
7 Sediment Forebay Volume (if required)	Vol_{pre} = ________ acre-ft

Notes: ____________________

Design Checklist: Sand Filter

Project: ____________________

Form Completed By: ____________ Date: ____________

Form Checked By: ____________ Date: ____________

1. Computed WQv	
WQ_v	WQ_v = ________ acre-ft
2. Drainage Area	
Area	A = ________ acre(s)
3. Diversion Structure	
Low Flow Orifice - Orifice Equation	A = ________ ft^2
Orifice Diameter	diam. = ________ in
4. Filtration Area	
Area - Darcy's Law	A_f = ________ ft^2
Filter Length	L = ________ ft
Filter Width	W = ________ ft
Sand Depth	D = ________ in
5. Sediment Forebay	
Area - Camp-Hazen Equation	A_s = ________ ft^2
Length	L = ________ ft

Notes: ____________________

Hydraulic Grade Line Computations

Designed by ____________________
Checked by ____________________
QA /QC Verification ____________________

Project Name ____

Location ____

Catch Basin, Drop Inlet or Junction No.	Outlet W.S. Elevation	Pipe diameter (inches)	Discharge (cfs)	Pipe Length (feet)	Head Losses (feet)					Inlet W.S. Elevation	RIM Elevation	Remarks
					H(f)	H(c)	H(e)	H(b)	Total			

BEND LOSS COEFFICENTS

Degrees	K	Degrees	K	Degrees	K
0	0.00	30	0.28	70	0.61
15	0.10	40	0.38	80	0.66
20	0.16	50	0.47	90	0.70
25	0.22	60	0.55		

Storm Drain Design Computations

Project Name ______________________________

Location ______________________________

Designed by ______________________
Checked by ______________________
QA /QC Verification ______________________

STRUCTURE		DISCHARGE								Pipe Design								
From	To	Cum. D.A.	Sum (C)(D.A.)	Pipe length	Inlet time	Flow time	Design time	Rainfall intensity	Discharge	Inlet elevation	Outlet elevation	Slope	Diameter	Material	Pipe capacity	Flow velocity	Upstream box depth	Remarks
		(Acres)		(feet)	[min.]	[min.]	[min.]	(in/hr)	(cfs)			(ft/ft)	(inches)		(cfs)	[fps]	(feet)	

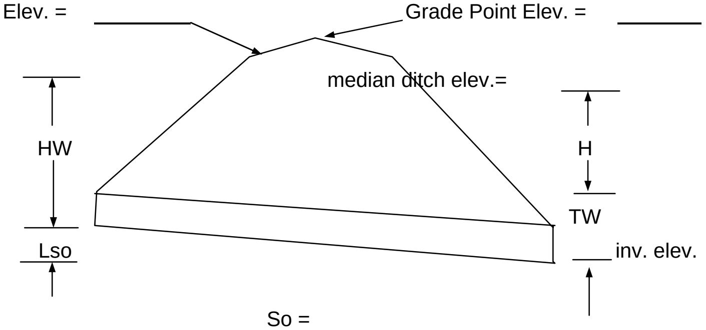
Culvert Design Form

Date

Project Name:.

Designed By

Checked By

Culvert Location Skew Size/Type Pipe Type Entrance Direction of Flow Hydrologic Method H.W. Control Elev.	Shoulder Elev. = ______ Grade Point Elev. = ______  So = L=	**SUMMARY DATA** Drainage Area = Design Frequency = Design Discharge = Design H.W. Elev = Q100 Discharge = Q100 H.W. Elev. = Depth above road =

Size (ft)		No.	"n"	Type	Freq.	Total Q	Nat.	Allow.	T.W.	INLET CONTROL		OUTLET CONTROL							H.W.	Vo	Comments
D	B			Pipe	(yrs)	(cfs)	H.W.	H.W.	Elev.	HW/D	H.W.	Ke	dc	dc+D/2	ho	H	Lso	H.W.	Elev.	(fps)	

SUMMARY AND RECOMMENDATIONS:

APPENDIX C: REFERENCES

City of Raleigh, Stormwater Management Design Manual - Draft, Central Engineering Department, City of Raleigh, North Carolina, January 2002.

Charlotte Mecklenburg, Storm Water Design Manual, City of Charlotte and Mecklenburg County, North Carolina, July 1993.

Georgia Stormwater Management Manual, Volumes 1 and 2, August 2001

2000 Maryland Stormwater Design Manual, Volumes 1 and 2, Center for Watershed Protection and Maryland Department of the Environment

Guidelines for Drainage Studies and Hydraulic Design, North Carolina Department of Transportation, 1999

Elements of Urban Stormwater Design, Dr. H. Rooney Malcolm, North Carolina State University, 1989.

North Carolina, Erosion And Sediment Control Planning And Design Manual, North Carolina Sedimentation Control Commission, North Carolina Department of Natural Resources And Community Development, 1988.

North Carolina, Tar-Pamlico Basin: Model Stormwater Program, North Carolina Division of Water Quality, North Carolina Department of Natural Resources And Community Development, 1999

American Association Of State Highway And Transportation Officials, Model Drainage Manual, 1992.

Federal Highway Administration. 1991. HYDRAIN Documentation.bb

Georgia Soil and Water Conservation Commission, Manual For Erosion And Sediment Control In Georgia, Fourth Edition, P.O. Box 8024, Athens, Georgia 30603, 1996.

Hershfield, D. M., “Rainfall Frequency Atlas of the United States”, Technical Paper 40, 1961.

Maestri, B. and others, "Managing Pollution From Highway Stormwater Runoff", Transportation Research Board, National Academy of Science, Transportation Research Record Number 1166, 1988.

Metropolitan Washington Council of Governments, A Current Assessment Of Urban Best Management Practices - Techniques for Reducing Non-Point Source Pollution in the Coastal Zone, 777 North Capital Street, Suite 300, Washington, D.C., 1992.

Metropolitan Washington Council of Governments, Controlling Urban Runoff: A Practical Manual for Planning and Selecting Urban BMPs, 777 North Capital Street, Suite 300, Washington, D.C., 1987.

NOAA, "Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States", NOAA Tech. Memo. NWS HYDRO-35, 1977.

Overton, D. E. and M. E. Meadows. 1976. Storm water modeling. Academic Press. New York, N.Y. pp. 58-88.

U. S. Department of Agriculture, Soil Conservation Service, Engineering Division. 1986. Urban hydrology for small watersheds. Technical Release 55 (TR-55).

U. S. Department of Transportation, Federal Highway Administration. 1984. Hydrology. Hydraulic Engineering Circular No. 19.

Water Resources Council Bulletin 17B. 1981. Guidelines for determining flood flow frequency.

Wright-McLaughlin Engineers. 1969. Urban storm drainage criteria manual. Vol. I and II. Prepared for the Denver Regional Council of Governments, Denver, Colorado.