

Contents

Section 1 - Introduction

1.1	Background	1-1
1.2	Why a BMP Manual?	1-1
1.3	How to Use This Manual.....	1-2
1.4	Definitions and Acronyms	1-4
1.5	References	1-6

Section 2 – Implementation Guidelines

2.1	Applying BMPs to Development Practices.....	2-1
2.2	Guidelines for BMPs in Series (Treatment Train)	2-4
2.3	Design Considerations for BMP Implementation.....	2-5
2.3.1	Planning and Design (Section 3 and Section 4).....	2-5
2.3.2	Construction Practices (Section 4 and Section 5)	2-6
2.3.3	Maintenance and Inspection (Section 5)	2-6
2.4	Public Outreach	2-7
2.5	References	2-8

Section 3 – Non-Structural BMPs

3.1	Stream Buffers	3-1
3.1.1	Stream Buffer Policy Definition	3-1
3.1.2	A Typical Stream Buffer	3-1
3.1.3	Proposed Stream Buffer Guidelines	3-2
3.1.4	Implementation	3-3
3.1.5	References	3-3
3.2	Preserve Existing Native Vegetation.....	3-5
3.2.1	Goals	3-6
3.2.2	Preservation Process	3-6
3.2.3	Maintenance.....	3-7
3.2.4	References	3-8
3.3	Restoration of Native Vegetation	3-9
3.3.1	Goals	3-10
3.3.2	Restoration Process	3-10
3.3.3	Maintenance.....	3-10
3.3.4	References	3-11

Section 4 – Structural BMPs

4.1	Hydrology Methods.....	4-1
4.1.1	Water Quality Volume (WQv)	4-1
4.1.1.1	Short-Cut Method (Claytor and Schueler 1996).....	4-2

	4.1.1.2	Small Storm Hydrology Method (Claytor and Schueler 1996).....	4-2
	4.1.2	Rational Method.....	4-3
	4.1.3	References	4-5
4.2		Lot Level BMPs	4-7
	4.2.1	Rain Gardens	4-9
	4.2.1.1	General Application.....	4-10
	4.2.1.2	Design Requirements.....	4-11
	4.2.1.3	Submittal Requirements	4-13
	4.2.1.4	Web-Based Resources	4-13
	4.2.1.5	References.....	4-14
	4.2.2	Rain Barrel and Cisterns.....	4-15
	4.2.2.1	Rain Barrels	4-15
	4.2.2.2	Cisterns	4-17
	4.2.3	Disconnect Impervious Areas.....	4-19
	4.2.3.1	General Application.....	4-19
	4.2.3.2	Design Requirements.....	4-19
4.3		Bioretention.....	4-21
	4.3.1	General Application.....	4-22
	4.3.2	Advantages and Disadvantages	4-23
	4.3.3	Design Requirements and Considerations	4-23
	4.3.3.1	Overall Design Guidance	4-23
	4.3.3.2	Excavation	4-24
	4.3.3.3	Underdrain/Outlet	4-24
	4.3.3.4	High Flow Structures.....	4-25
	4.3.3.5	Bioretention Soil Mixture (BSM)	4-26
	4.3.3.6	Ponding Area	4-26
	4.3.3.7	Flow Entrance	4-26
	4.3.3.8	Vegetation.....	4-27
	4.3.4	Design Calculations	4-27
	4.3.5	Design Example.....	4-30
	4.3.5.1	Basin Water Quality Volume	4-30
	4.3.5.2	Pretreatment.....	4-30
	4.3.5.3	Planting Soil Bed and Ponding Area	4-30
	4.3.5.4	Underdrain	4-31
	4.3.5.5	Overflow	4-32
	4.3.5.6	Vegetation.....	4-32
	4.3.6	Submittal Requirements.....	4-32
	4.3.7	References	4-33
4.4		Vegetated Swales.....	4-35
	4.4.1	General Application.....	4-35
	4.4.2	Advantages and Disadvantages	4-36
	4.4.3	Design Requirements and Considerations	4-36
	4.4.3.1	General Guidance.....	4-36

	4.4.3.2	Site Location and Soils	4-37
	4.4.3.3	Slope, Shape and Design	4-37
	4.4.4	Design Calculations	4-39
	4.4.5	Design Example.....	4-39
	4.4.6	Submittal Requirements.....	4-40
	4.4.7	References	4-41
4.5		Filter Strips.....	4-40
	4.5.1	General Application.....	4-43
	4.5.2	Advantages and Disadvantages	4-44
	4.5.3	Design Requirements and Considerations	4-45
	4.5.3.1	General Guidelines.....	4-45
	4.5.3.2	Site Location and Soils	4-45
	4.5.3.3	Slope	4-46
	4.5.3.4	Shape and Design.....	4-46
	4.5.4	Design Calculations	4-46
	4.5.5	Design Examples	4-48
	4.5.5.1	Time of Concentration (T_1)	4-48
	4.5.5.2	Ten Year Rainfall Intensity (I_{10})	4-48
	4.5.5.3	Maximum Pavement Length (PL_{MAX}).....	4-48
	4.5.5.4	Water Quality Event Intensity (WQ_1)	4-49
	4.5.5.5	Minimum Filter Length (FS_{MIN}).....	4-49
	4.5.6	Submittal Requirements.....	4-49
	4.5.7	References	4-49
4.6		Infiltration Trench.....	4-51
	4.6.1	General Application.....	4-52
	4.6.2	Advantages and Disadvantages	4-52
	4.6.3	Design Requirements and Considerations	4-53
	4.6.3.1	General Requirements	4-53
	4.6.3.2	Location and Soils	4-53
	4.6.3.3	Slope	4-54
	4.6.3.4	Design Specifications	4-54
	4.6.4	Design Examples.....	4-55
	4.6.5	Submittal Requirements.....	4-58
	4.6.6	References	4-59
4.7		Extended Dry Detention.....	4-61
	4.7.1	General Application.....	4-62
	4.7.2	Advantages and Disadvantages	4-63
	4.7.3	Design Requirements and Considerations	4-63
	4.7.3.1	Site Requirements.....	4-63
	4.7.3.2	Basin Dimensions	4-64
	4.7.3.3	Basin Configuration	4-65
	4.7.3.4	Vegetation.....	4-66
	4.7.4	Design Calculations	4-66
	4.7.5	Design Example.....	4-68

4.7.5.1	Basin Water Quality Volume (Step 1).....	4-68
4.7.5.2	Water Quality Outlet (Step 2)	4-68
4.7.5.3	Flood Control.....	4-69
4.7.5.4	Trash Racks (Step 3).....	4-69
4.7.5.5	Basin Shape	4-69
4.7.5.6	Forebay (Step 4)	4-70
4.7.5.7	Basin Side Slopes (Step 5).....	4-70
4.7.5.8	Dam Embankment Side Slopes (Step 5)	4-70
4.7.5.9	Vegetation (Step 6)	4-70
4.7.5.10	Inlet Protection.....	4-71
4.7.5.11	Access.....	4-71
4.7.6	Submittal Requirements.....	4-71
4.7.7	References	4-71
4.8	Extended Wet Detention.....	4-73
4.8.1	General Application.....	4-74
4.8.2	Advantages and Disadvantages	4-75
4.8.3	Design Requirements and Considerations	4-75
4.8.3.1	Site Requirements.....	4-75
4.8.3.2	Basin Dimensions	4-76
4.8.3.3	Basin Configuration	4-77
4.8.3.4	Vegetation.....	4-79
4.8.3.5	Potential Treatment Train Options	4-79
4.8.4	Design Calculations	4-80
4.8.5	Design Example.....	4-73
4.8.5.1	Basin Water Quality Volume (Step 1).....	4-73
4.8.5.2	Permanent Pool Volume (Step 2)	4-84
4.8.5.3	Outlet (Step 3)	4-85
4.8.5.4	Trash Racks (Step 4).....	4-86
4.8.5.5	Forebay (Step 5)	4-86
4.8.5.6	Littoral Bench (Step 6).....	4-87
4.8.5.7	Basin Side Slopes (Step 7).....	4-87
4.8.5.8	Dam Embankment Side Slopes (Step 7)	4-87
4.8.5.9	Vegetation (Step 8)	4-87
4.8.5.10	Inlet Protection.....	4-88
4.8.5.11	Access.....	4-88
4.8.6	Submittal Requirements.....	4-91
4.8.7	References	4-91

Section 5 – BMP Inspection and Maintenance

5.1	Importance of BMP Maintenance.....	5-1
5.2	Fitting BMPs into the Development “Box”	5-1
5.2.1	BMP Construction Timing and Acceptance	5-1
5.2.2	Performance and Maintenance Agreements.....	5-2
5.3	Delegating BMP Maintenance Tasks	5-3

5.3.1	Developer/Contractor Responsibilities	5-3
5.3.2	Non-Professional/Professional.....	5-3
5.4	BMP Maintenance Tasks.....	5-3
5.4.1	Vegetated BMPs	5-6
5.4.1.1	Short-term.....	5-6
5.4.1.2	Long-term.....	5-9
5.4.2	Non-Vegetated BMPs	5-11
5.4.2.1	Short-term.....	5-11
5.4.2.2	Long-term.....	5-13

Appendices

<i>Appendix A</i>	Hydrologic Information
<i>Appendix B</i>	Soils Information
<i>Appendix C</i>	Vegetation Information
<i>Appendix D</i>	Maintenance Tables
<i>Appendix E</i>	Example Stream Buffer Ordinance
<i>Appendix F</i>	Example BMP Brochure
<i>Appendix G</i>	Detention Outlet Structure Calculations
<i>Appendix H</i>	BMP Implementation Determination by City
<i>Appendix I</i>	Post Construction Stormwater Ordinances

Figures

Figure 2-1	Recommended Format for a BMP Informational Sign	2-8
Figure 3-1	Example of Stream Buffer Zones.....	3-2
Figure 3-2	Tall-grass Prairie Alongside McDowell Creek Road Outside of Manhattan, KS (City-Data.com)	3-6
Figure 3-3	Cluster Land Development Schedule With Schematics of Development Scenarios (DNREC, 1997)	3-7
Figure 3-4	Native Vegetation Area That Serves as a Stormwater BMP, Wildlife Habitat and Aesthetic Area (US Army Corps, 2000)	3-9
Figure 4-1	Rain Garden at University of Missouri-Kansas City	4-9
Figure 4-2	Example Placement of Rain Gardens Within a Residential Lot	4-11
Figure 4-3	Example of Where to Place Excavated Soil When Building Rain Garden (University of Wisconsin-Extension, 2003)	4-12
Figure 4-4	(left) Rain Barrel Diagram (townofblackmountain.org) (right) Residential Rain Barrel in River Falls, Wisconsin (rfcity.org)	4-16
Figure 4-5	Residential Aboveground Cistern in Portland, Oregon (www.rwh.in)	4-18
Figure 4-6	Sidewalk Median in Topeka, KS Provides Pervious Area	4-19
Figure 4-7	Typical Lot Diagram (Adapted From Portland, 2008)	4-20
Figure 4-8	Sprint Campus in Overland Park Provides Pervious Area Around Buildings for Downspout Discharge	4-20
Figure 4-9	Series of Bioretention Cells on Jackson Street, Topeka, Kansas (Source: GreenTopeka.org)	4-22
Figure 4-10	Underdrain Configuration Side View (Source: MARC, 2008)	4-24
Figure 4-11	Bioretention Underdrain Example.....	4-25
Figure 4-12	Mize Lake, Lenexa, Kansas Bioretention High Flow Structure	4-26
Figure 4-13	Vegetated Swale Guides Runoff From Surrounding Parking Lots Into Bioretention Cell Kansas City, MO (Source: CDM).....	4-27
Figure 4-14	Bioretention Plan and Profile Source: MARC, 2008	4-28
Figure 4-15	Grass Swale Located Near a Roadway (Source: US Army Corps).....	4-36
Figure 4-16	Example of a Swale Cross Section (Source: Center for Watershed Protection, 2001)	4-38
Figure 4-17	Filter Strip	4-44
Figure 4-18	Site Plan of 1 Acre Small Business Site in Winfield, KS.....	4-48
Figure 4-19	Surface View of an Infiltration Trench (Photo: MARC, 2008).....	4-52
Figure 4-20	Infiltration Trench Design (Source: Schueler, 1987)	4-55
Figure 4-21	Observation Well Details	4-58
Figure 4-22	Extended Dry Detention Basin Located at an Industrial Location.....	4-62
Figure 4-23	Schematic of an Extended Dry Detention Basin	4-65
Figure 4-24	Extended Wet Detention Basin with Landscaping and Recreational Components	4-74
Figure 4-25	Cross Sectional View of Extended Wet Detention Basin.....	4-78

Figure 4-26	Relationship Between TSS Removal and the Ratio of WQV to Runoff Volume (VB/R).....	4-82
Figure 4-27	WQv Outlet Trash Rack Design (UDFCD, 2005)	4-89
Figure 4-28	Alternative WQv Outlet Trash Rack Design (UDFCD, 2005)	4-90
Figure 5-1	Sample BMP Construction Record	5-6

Equations

Equation 4.1	Volumetric Runoff Coefficient.....	4-2
Equation 4.2	Water Quality Volume (Short-Cut Method).....	4-2
Equation 4.3	Weighted volumetric runoff coefficient.....	4-3
Equation 4.4	Water Quality Volume (Small Storm Method)	4-3
Equation 4.5	Runoff Coefficient (Rational Method)	4-4
Equation 4.6	Peak Runoff Rate (Rational Method).....	4-4
Equation 4.7	Time of Concentration	4-4
Equation 4.8	Overland Flow Time	4-5
Equation 4.9	Channelized Travel Time	4-5
Equation 4.10	Filter Bed Surface Area	4-29
Equation 4.11	Filter Bed Length (Assuming L:W = 2:1).....	4-29
Equation 4.12	Number of Transverse Collector Pipes	4-29
Equation 4.16	Water Quality Outflow Rate	4-67
Equation 4.22	Forebay Volume	4-67
Equation 4.23	Forebay Surface Area	4-67
Equation 4.24	14 day permanent pool volume (acre feet)	4-80
Equation 4.25	Impervious tributary area (acre)	4-81
Equation 4.26	Sedimentation permanent pool volume.....	4-81
Equation 4.27	Surface area of permanent pool.....	4-81
Equation 4.34	Littoral bench surface area	4-83
Equation 4.35	Littoral bench width.....	4-83

Tables

Table 2-1	Infiltration Rates by HSG	2-2
Table 2-2	Development Matrix for BMP Application	2-3
Table 2-3	BMP Earliest Installation	2-4
Table 2-4	Treatment Trains and Water Quality Benefits.....	2-5
Table 3-1	Minimum Stream Buffer Width (Inner Zone plus Outer Zone(s))	3-2
Table 4-1	BMP Hydrologic Calculation Types	4-1
Table 4-2	The 90-percent and 85-percent Water Quality Rainfall Event by City	4-1
Table 4-3	Volumetric Coefficients for Urban Runoff for Directly Connected Impervious Areas (adapted from Pitt, 1987).....	4-2
Table 4-4	Reduction Factors to Volumetric Runoff Coefficients for Disconnected Impervious Surfaces (adapted from Pitt, 1987).....	4-3
Table 4-5	Total Runoff Volume Generated Based on Roof's Square Footage.....	4-16
Table 4-6	Maximum Pavement Length in Feet ($n=0.011$) Allowable for a Given Pavement Slope.....	4-47
Table 4-7	Minimum Filter Strip Length ($n=0.24$) for a Minimum Travel Time = 3 Minutes.....	4-47
Table 4-8	Threshold Tributary Areas to EWDB (MARC, 2008)	4-77
Table 4-9	Fourteen Day Wet Season Rainfall Depth (R_{14}) and Mean Storm Depth (S_d) for Phase II Kansas Cities	4-81
Table 5-1	Sample Construction and Long-Term Schedule for Project Construction, BMP Installation, and BMP Maintenance.....	5-5
Table 5-2	Short-Term Maintenance Tasks For Vegetated BMP	5-8
Table 5-3	Long-Term Maintenance Tasks For Vegetated BMP	5-10
Table 5-4	Short-Term Maintenance Tasks For Non-Vegetated BMP	5-12
Table 5-5	Long-Term Maintenance Tasks For Non-Vegetated BMP.....	5-14