OMAHA REGIONAL BMP MANUAL

Recent Updates to Stormwater Design Manual

CDM Smith

Omaha Regional Post-Construction Stormwater BMP Design Manual Update

Andy Sauer, P.E.
Principal
Water Resources Group Leader

March 21, 2012

Today's Presentation

- Project Team
  - Technical Review Committee
  - Stakeholder Meetings
- Manual update goals
- Process (Phases)
- Typical sections for a BMP manual
- Major Updates
  - BMP design hydrology
  - Design guidelines
  - LID incentives

Project Team

- CDM Smith Team
  - Andy Sauer, Project Manager
  - Mike Beezhold, Facilitator/BMP Implementation
  - Natalie Postel, Project Engineer
  - Dan Bounds, Technical Review
  - John Aldrich, Technical Review
- Technical Review Team
  - **City of Omaha**
    - **Nina Cudahy**
    - Selma Kessler
    - Andy Szatko
  - Papio Natural Resources District (NRD)
  - City of Papillion
  - City of La Vista
- Others
  - Jesse Poore, FHU
  - Pat Nelson, CSO PMT
  - Emily Holtzclaw, CSO PMT

Manual Update Goals

- "State of the practice" for Post Construction BMP Design Guidelines
- Robust technical review process
  - Technical review committee
  - Stakeholder meetings
- Develop a more usable manual
- Provide a wider range of BMPs
- Provide additional detail and examples
- Needed to meet the needs of the region
- <u>**Not updating or changing existing stormwater ordinance**</u>

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Project Phases

- Phase 1 – Needs Assessment
  - Stakeholder Meeting – March 24, 2011
  - Progress Meetings
- Phase 2 – BMP Manual Updates
  - Progress Meetings
  - Draft BMP Manual – August 2011
  - Stakeholder Meeting – December 1, 2011
- Phase 3 – Finalize BMP Manual
  - Added two additional BMPs
  - Incorporated review comments
  - Held a stakeholder meeting
  - Finalize BMP Manual – April 2012

Technical Review Team - BMP Manual Improvement Needs

- Provide necessary design guidance and be usable for both designers and reviewers.
- Focus on the technical aspects of post-construction BMP design and avoid anything that would require revising the ordinance.
- Remove or put less emphasizes on nonstructural BMPs, such as education and outreach, that are specific to NPDES MS4 permit.
- Provide design guidelines that can be used for in the CSO basins for Green Infrastructure improvements.
- Updates must work with existing ordinance

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Stakeholder Input – BMP Manual Improvement Needs

- Need more design guidance for a greater array of BMPs including proprietary systems (manufactured systems)
- Operations and maintenance costs should be part of the decision process
- Standardize – specifications, templates and software/model applications
- Consider LID, conservation subdivision and stream buffer options
- Allow credits/incentives for preservation, disconnection of impervious area and treatment train
- Additional guidance on determining design peak flows as expressed on the 1-year 20-minute policy

Existing Manual vs. Updated Manual

- 8.1 Overview
- 8.2 General Water Quality Management Approach
- 8.3 Structural BMPs
  - Extended Dry Detention
  - Retention (Wet) Ponds
  - Constructed Wetlands
  - Grassed Swales
  - Filter Strips & Flow Spreaders
  - Sand Filters
  - Turf Paving
  - Oil/Grit Separators
  - Grate Inlet Inserts

- 8.1 Overview
  - Introduction
  - **Structural and Nonstructural BMPs**
- **8.2 BMP Selection and Implementation Guidelines**
- **8.3 BMP Hydrology**
- **8.4 Post-Construction Stormwater Management Plan**
- **8.5 References**
- **8.6 Lot-Level BMPs**
  - Rain Gardens in Residential Areas
  - Rain Barrels and Cisterns for Residential Use
  - Residential Disconnection of Impervious Area

Existing Manual vs. Updated Manual (Cont.)

- 8.3 Structural BMPs
  - Extended Dry Detention
  - Retention (Wet) Ponds
  - Constructed Wetlands
  - Grassed Swales
  - Filter Strips & Flow Spreaders
  - Sand Filters
  - Turf Paving
  - Oil/Grit Separators
  - Grate Inlet Inserts
- 8.4 Nonstructural BMPs
  - 10 Total
  - 8 MS4 Permit Compliance
- References

- 8.7 Structural BMPs
  - **Bioretention Garden**
  - Constructed Wetlands
  - Extended Dry Detention Basins
  - Grass Swales and Filter Strips
  - **Eco-Roof**
  - **Manufactured Systems**
  - **Permeable Pavement**
  - Retention Wet Ponds
  - **Soil Conditioning**
- **8.8 Lot Level/Homeowner Nonstructural Best Management Practices**
  - Lawn Care and Landscape Maintenance
  - Trash and Pet Waste Reduction
  - Sweeping and Cleaning of Impervious Areas
- Appendix

8.2 BMP Selection and Implementation Guidelines

- Define Project Objectives and Performance Standards
- Selecting BMPs based on:
  - Target Pollutant Removal
    - Estimate annual pollutant loads and pollutant removal of by BMPs
  - Physical Site Design Considerations
  - Cost Considerations
  - Selecting BMPs for Combined Sewer Areas
  - Selecting BMPs for Special Situations
    - Linear Projects
    - Underground Detention
    - Redevelopment and Retrofit

8.2 BMP Selection and Implementation Guidelines (Cont.)

- 8.2.3 Guidelines for BMPs in Series (Treatment Train)

Table 8-8
BMP Treatment Trains

	Second BMP in Series						
First BMP in Series	Infiltration Trench	Filter Strip	Vegetated Swale	Rain Garden	Bioretention	Extended Wet Detention	Extended Dry Detention Basin
Filter Strip	H	NA	L	H	H	M	M
Vegetated Swale	H	L	NA	M	H	M	L
Bioretention[1]	NA	NA	M	NA	NA	M	M
Extended Wet Detention	NA	NA	L	NA	NA	L	M
Extended Dry Detention Basin	NA	NA	L	NA	NA	L	L
H	High						
M	Medium						
L	Low						

[1] Assumes underdrain system.

8.2 BMP Selection and Implementation Guidelines (Cont.)

- 8.2.4 Low-Impact Development Guidelines
  - 8.2.4.1 Conservation Measures
    - Cluster & Conservation Subdivision Design
    - Stream Setback
    - Tree Protection
    - Sensitive Sites
  - 8.2.4.2 Impact Minimization
    - Soil Preservation
    - Streets
    - Alleys
    - Rural Zoning or Cluster Subdivision
    - Parking
    - Shared Parking
    - Landscaping
    - Streetscaping
    - Parking Landscaping

8.3 BMP Hydrology

- Water Quality Control Volume (WQCV)
  - 0.5 inches X Drainage Area
  - **Allow exclusion for areas that are preserved or impacted areas that meet the soil condition requirements**
- Water Quality Discharge (Q_{WQ})
  - Equivalent to capturing and controlling the first one-half inch (0.5”) of stormwater runoff
  - Set at 1.5 cfs per acre for sites with a time of concentration equal to or less than 10 minutes
  - Appendix E shows derivation of Q_{WQ}

8.3 BMP Hydrology (Cont.) – Appendix E

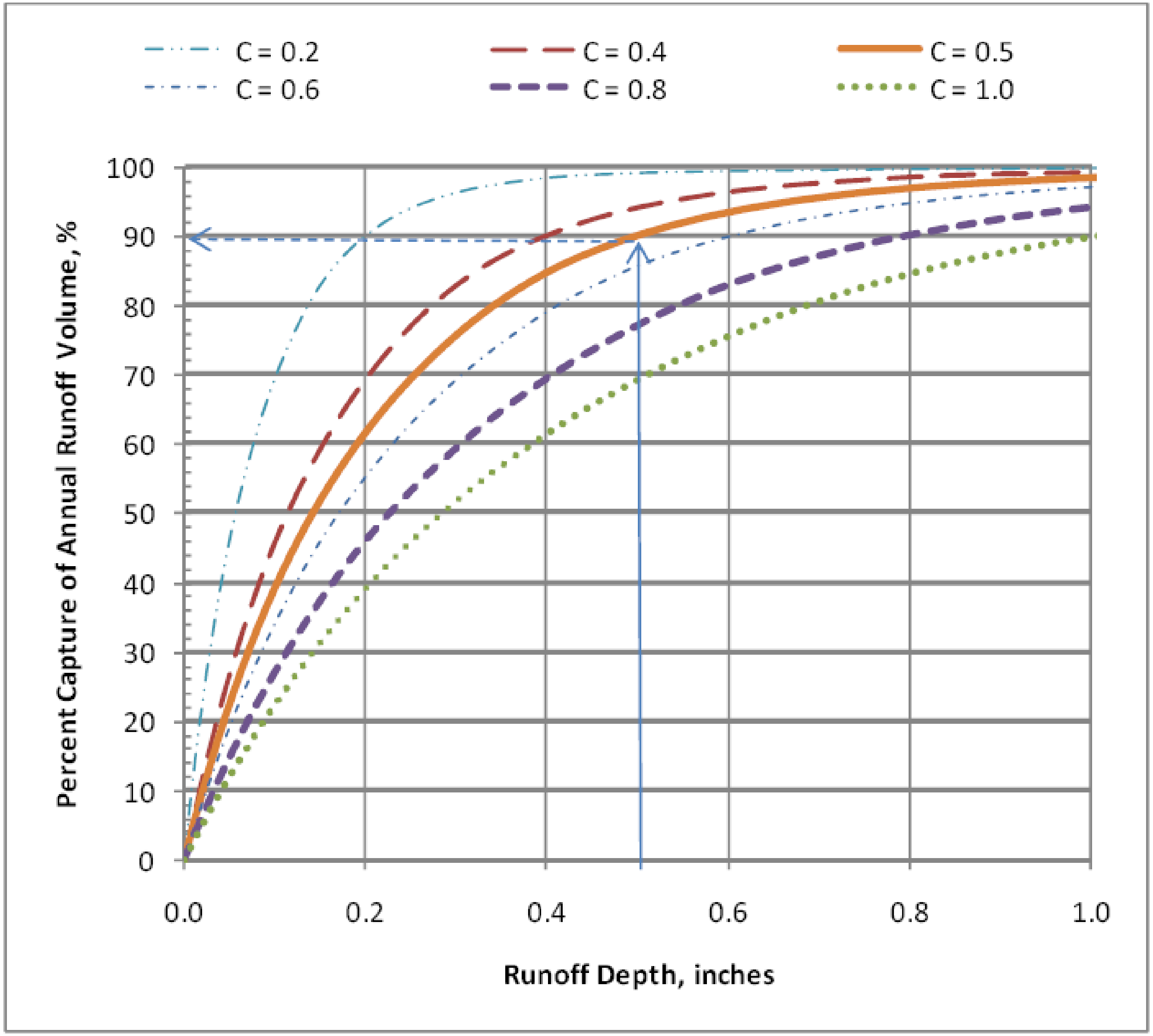


Figure 1 Capture Curves for Omaha, Nebraska for BMP with 24-hour draindown time.

8.3 BMP Hydrology (Cont.) – Appendix E

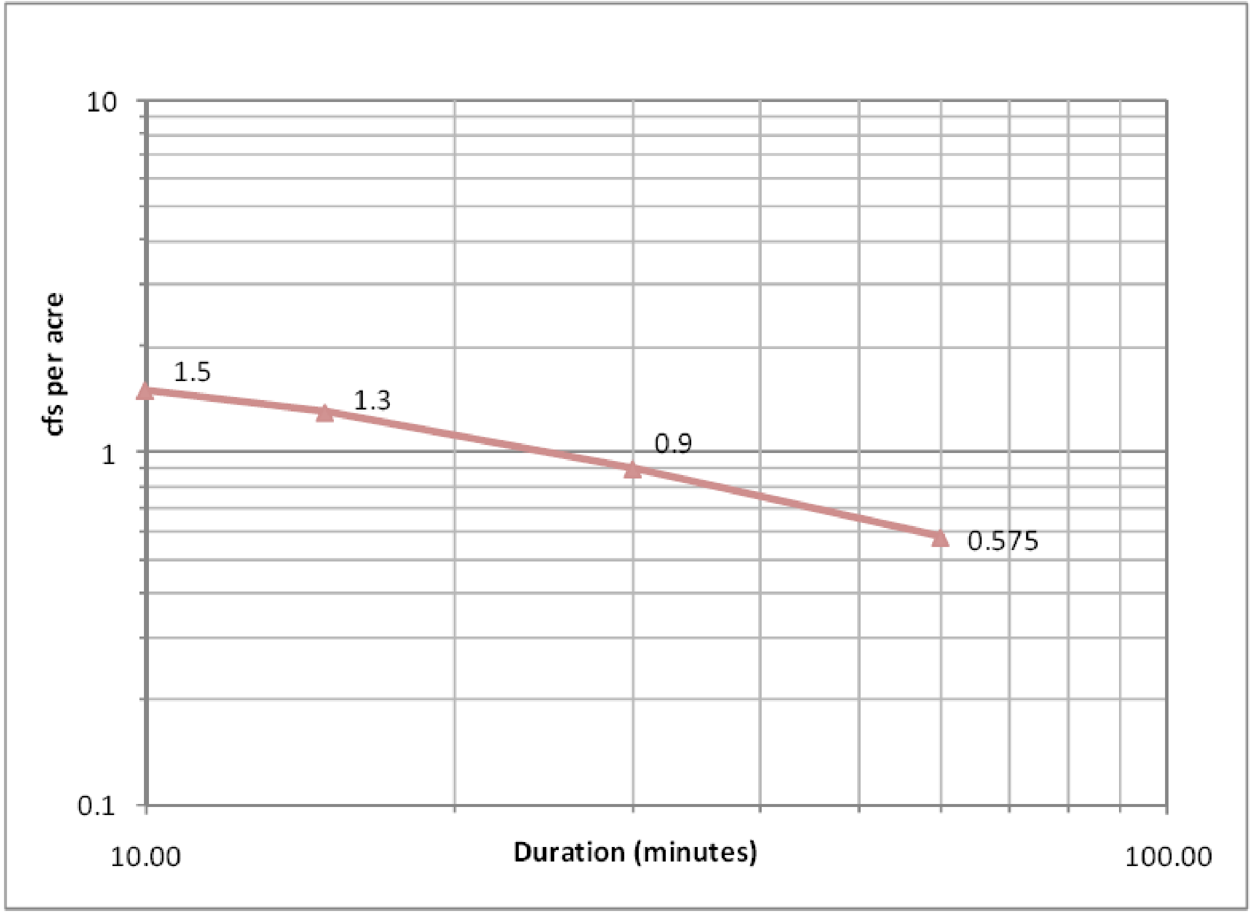


Figure 3 CFS Per Acre for C=0.5 and 90-Percent Intensity

8.3 BMP Hydrology

- Determining the BMP Water Budget for Vegetated Systems
  - Direct precipitation
  - Runoff from tributary areas
  - Evapotranspiration
    - Table of Monthly mean Pan Evaporation (Omaha Region)
  - Outflow
  - Infiltration
  - Recommendations and guidance for:
    - Growing season
    - Number of days for saturated or inundation for wetlands

8.3 BMP Hydrology – Adjustments for disconnected impervious/LID

- Design volume calculation for BMPs downstream of Cascading Planes (e.g. runoff surfaces)
  - Adjustment to WQCV controlled by pervious areas
  - Based on percent impervious & soil types pervious area
- Based on Urban Drainage & Flood Control District of Denver approach
- Appendix F

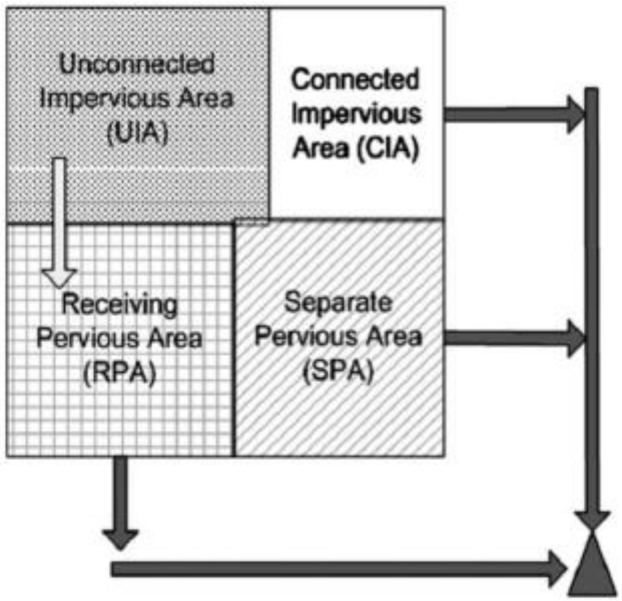


Figure 8-6 Schematic of Cascading Planes Concept. Source: Guo, et.al. Incentive Index Developed to Evaluate Storm-Water Low-Impact Designs. ASCE Journal of Environmental Engineering December 2010.

Cascading Planes – Impervious to Pervious

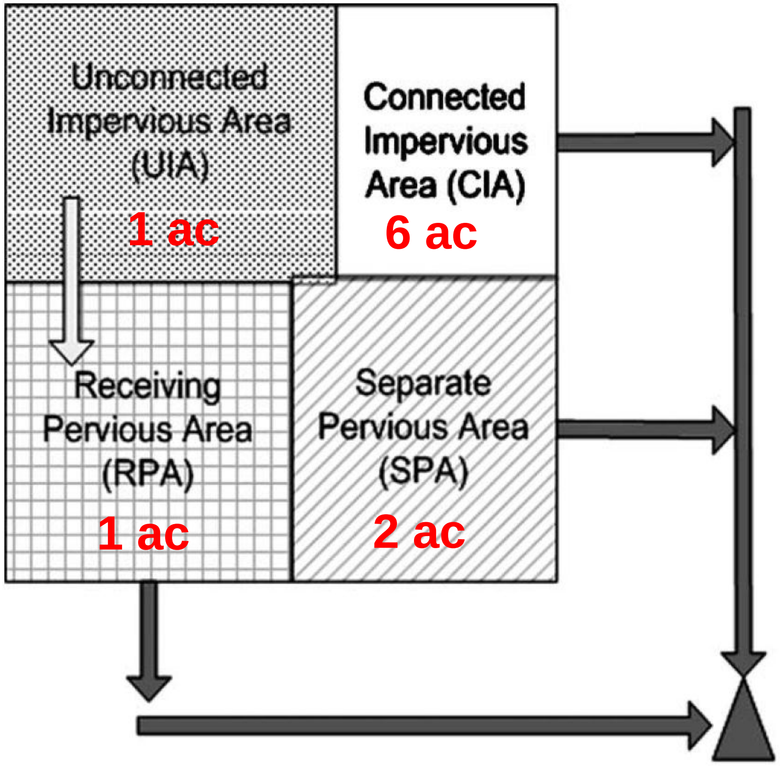
Table 8-11
Depth of Runoff Controlled (in inches) by Cascading Planes

Percent Impervious of Cascading Planes, %	f, in/hr[1]								
	0.12	0.16	0.26	0.34	0.43	0.83	1.04	1.92	5.85
	Soil Texture Classification								
	Clay	Sandy Clay	Clay Loam	Sandy Clay Loam	Loam	Silt Loam	Sandy Loam	Loamy Sand	Sand
1	0.049	0.064	0.100	0.127	0.154	0.255	0.295	0.404	0.497
10	0.045	0.059	0.092	0.116	0.142	0.238	0.278	0.388	0.495
20	0.040	0.053	0.082	0.105	0.129	0.219	0.257	0.368	0.491
30	0.035	0.046	0.073	0.093	0.115	0.198	0.234	0.344	0.486
40	0.030	0.040	0.063	0.081	0.100	0.175	0.209	0.316	0.476
50	0.025	0.033	0.053	0.068	0.085	0.151	0.181	0.282	0.460
60	0.025	0.027	0.043	0.056	0.069	0.125	0.151	0.243	0.434
70	0.015	0.020	0.033	0.042	0.053	0.097	0.118	0.196	0.391
80	0.010	0.014	0.022	0.029	0.036	0.067	0.082	0.142	0.319
90	0.005	0.007	0.011	0.015	0.018	0.035	0.043	0.077	0.199
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

[1]Values for conveyance-based BMPs from Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual Volume 3, page 3-17

BMP Hydrology

- ***Example of Credit for Disconnected Impervious***
  - 1 ac of disconnected imp area
    - 1 ac of imp area to 1 ac of turf lawn on sandy-clay-loam soil (0.34 in/hr)
  - Calculated the % imp of the cascading planes:
    - I_A = 1 acre / (1 acre + 1 acres) = 50%
  - Table 8-11
    - I_A = 50%, f = 0.34 in/hr



Example – 50% Imp. & 0.34 in/hr

Table 8-11
Depth of Runoff Controlled (in inches) by Cascading Planes

Percent Impervious of Cascading Planes, %	f, in/hr[1]								
	0.12	0.16	0.26	0.34	0.43	0.83	1.04	1.92	5.85
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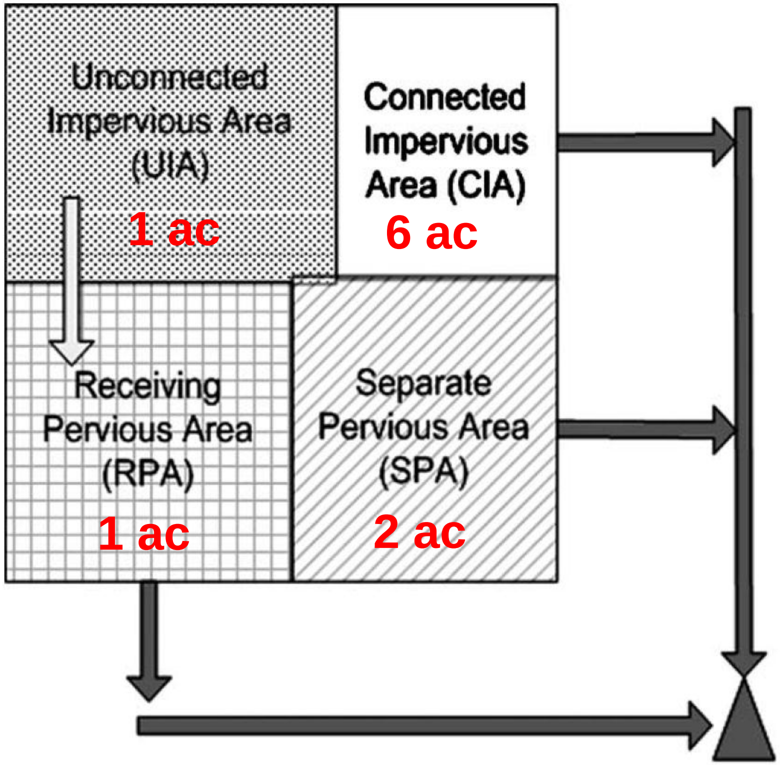
90	0.005	0.007	0.011	0.015	0.018	0.035	0.043	0.077	0.199
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

[1]Values for conveyance-based BMPs from Urban Drainage and Flood Control District Urban Storm Drainage Criteria Manual Volume 3, page 3-17

BMP Hydrology

- ***Calculating Disconnected Impervious Area Credit***
  - Table 8-11
    - I_A = 50%, f = 0.34 in/hr
      - 0.068 reduction
      - 0.5 in – 0.068 in = 0.432 in
      - Adjusted WQCV for 2 ac
  - Site WQCV =
    - (0.432 in * 2 ac/12)+(0.5 in * 8 ac/12
    - = **0.405 ac-ft**
    - 2.9% reduction (compared to 0.417 ac-ft)



8.4 Post Construction Stormwater Management Plan (PCSMP)

- Required by City of Omaha Public Works Dept.
- Requirement of submittal
  - Conceptual PCSMP
    - Conceptual PCSMP Application
    - Conceptual PCSMP Sheets
    - Preliminary BMP Design Information
    - Preliminary Drainage Study
  - Final PCSMP
    - Final PCSMP Application
    - Final PCSMP Sheets
    - Final BMP Design Information
    - Final Drainage Study
    - BMP Maintenance Requirements
    - Maintenance Agreement
  - BMP Certification

8.6 Lot-Level BMPs

- Aimed at smaller single lot residential properties
- Types
  - Rain Gardens
  - Rain Barrels and Cisterns
  - Residential Disconnection of Impervious Area

8.6 Lot-Level BMPs

- For each BMP:
  - General Application
  - Design Requirements and Considerations
  - Maintenance
  - Example
  - Additional Resources

- Layman terminology

Design and Installation Requirements

- **Components.** 50 to 60 gallon covered plastic tank with an opening at the top for downspout discharge, an overflow outlet, and a valve and hose adapter at the bottom. It is recommended that the barrel have a sealed, child resistant top that can be easily removed for cleaning. Figure 8-11 (adapted from Watershed Activities to Encourage Restoration (W.A.T.E.R.) image) shows the typical configuration of a rain barrel system.
- **Location.** Locate the barrel under downspouts where water can be easily collected for transport away from building foundations.
- **Installation Guidelines.** The base of the rain barrel must be level and secure. Concrete blocks or pavers can be used to achieve this. Downspouts should be cut to allow a three inch gap between the top of the barrel and the end of the downspout, allowing for space to remove the lid and clean the inside of the barrel. Overflow outlets should be routed away from foundations and to pervious areas. Additional rain barrels will increase the quantity of water stored. Table 8-12 provides the total runoff volume generated based on a roof's square footage and the amount of rainfall.

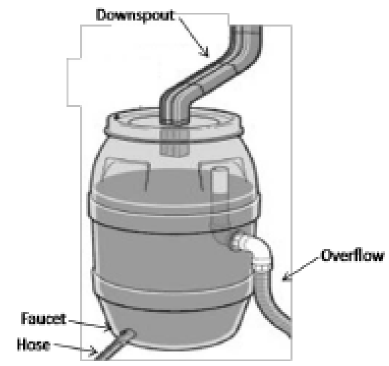


Figure 8-11 Rain Barrel Diagram

Table 8-12
Total Runoff Volume Generated Based on Roof's Square Footage

Gallons of Water Produced

Roof Area (square feet)	Rainfall (inches) 0.1	0.2	0.3	0.4	0.5*	0.6	0.7	0.8	0.9	1
100	6	12	18	24	30	36	41	47	53	59
250	15	30	44	59	74	89	104	118	133	148
500	30	59	89	118	148	178	207	237	266	296
750	44	89	133	178	222	266	311	355	400	444
1000	59	118	178	237	296	355	415	474	533	592
1250	74	148	222	296	370	444	518	592	666	740
1500	89	178	266	355	444	533	622	711	799	888
1750	104	207	311	415	518	622	725	829	933	1036
2000	118	237	355	474	592	711	829	947	1066	1184

* 0.5 inches equals WQCV

8.7 Structural BMPs

- Types
  - Bioretention Garden
  - Constructed Wetlands
  - Extended Dry Detention Basins
  - Grass Swales and Filter Strips
  - Eco-Roof
  - Manufactured Systems
  - Permeable Pavement
  - Retention Wet Ponds
  - Soil Conditioning

8.7.1.3 Design Requirements and Considerations

The procedure for designing a bioretention cell is outlined below. The design components are described in the order of construction starting with excavation for construction of the underdrain and continuing through bioretention media, planting soil, vegetation, ponding area, and high flow structures. Appendix E provides an example of a complete specification for a bioretention facility. A typical cross section is shown in Figure 8-18.

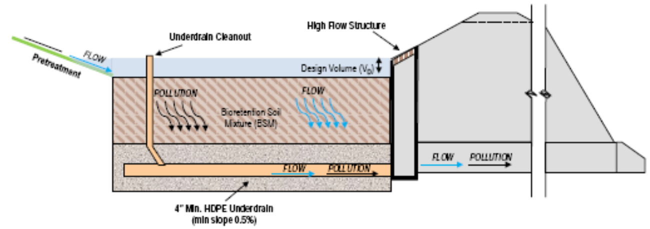


Figure 8-18 Cross Section Schematic of Bioretention Area

Overall Design Guidance

- Bioretention facilities should not be constructed until the entire drainage area is permanently stabilized against erosion or a pre-treatment practice is implemented or runoff is bypassed around the facility during construction and until the drainage area is stabilized. Heavy sediment loads to the cell will reduce infiltration rates and require reconstruction of the cell to restore its defined performance.
- The bioretention facility should be designed to capture at a minimum the required V_D. The design volume is equal to the WQCV unless routing of impervious areas to pervious areas (i.e. cascading planes) occurs within the drainage area of the bioretention cell. The WQCV is based on 0.5 inches of runoff. If cascading planes are present, the design volume can be reduced because a portion of the WQCV from the impervious area is infiltrated. Section 8.3.3 provides additional guidance on calculating the design volume for drainage areas with cascading planes.
- The footprint of the cell should be sized such that standing water is present less than 24 hours.
- The tributary area for a bioretention area should be less than 4 acres. Multiple bioretention areas may be required for larger tributary areas (EPA, 1999).

Excavation

Excavation is required to construct the bioretention underdrain system. The bioretention facility can be partially excavated to within 12 inches of elevation of the bottom of the bioretention soil mixture (BSM) before final stabilization of the tributary area and utilized for erosion and sediment purposes, such as a sediment basin. After stabilization is complete, all sediment should be cleared from the bioretention area and it should be excavated to the elevation of the underdrain system. The bioretention soil mixture and underdrain system should not be placed until the entire drainage area has been stabilized. Bioretention facility side slopes should be excavated at 4:1 or flatter. Low ground-contact pressure equipment, such as

8.7 Structural BMPs

- For Each BMP
  - Introduction/Design Considerations
  - General Application
  - Advantages and Disadvantages
  - Design Requirements and Considerations
  - Inspection and Maintenance
  - Submittal Requirements
  - Design Calculations
  - Example
  - References

8.7 Structural Best Management Practices

8.7.1 Bioretention

Bioretention uses storage volume and vegetation to accept and treat stormwater runoff through infiltration into layers of plant roots and the growing medium. Reductions in stormwater runoff are achieved via natural plant processes and movement through soil media. Runoff volumes are also decreased by temporary storage in the soil media and permanent removal by infiltration and evapotranspiration from the vegetation.

The design volume is allowed to infiltrate into the surrounding soil or be collected by an underdrain system that discharges to the storm sewer system at a rate that maximizes infiltration and mimics pre-development hydrology. Bioretention areas may be designed to reduce peak flow rates for the 2-year event; however, flows larger than the 2-year event should bypass the facility or be safely routed through the facility at a rate that meets large storm detention requirements. Thus, bioretention facilities can be designed to be on or off-line of existing stormwater systems.

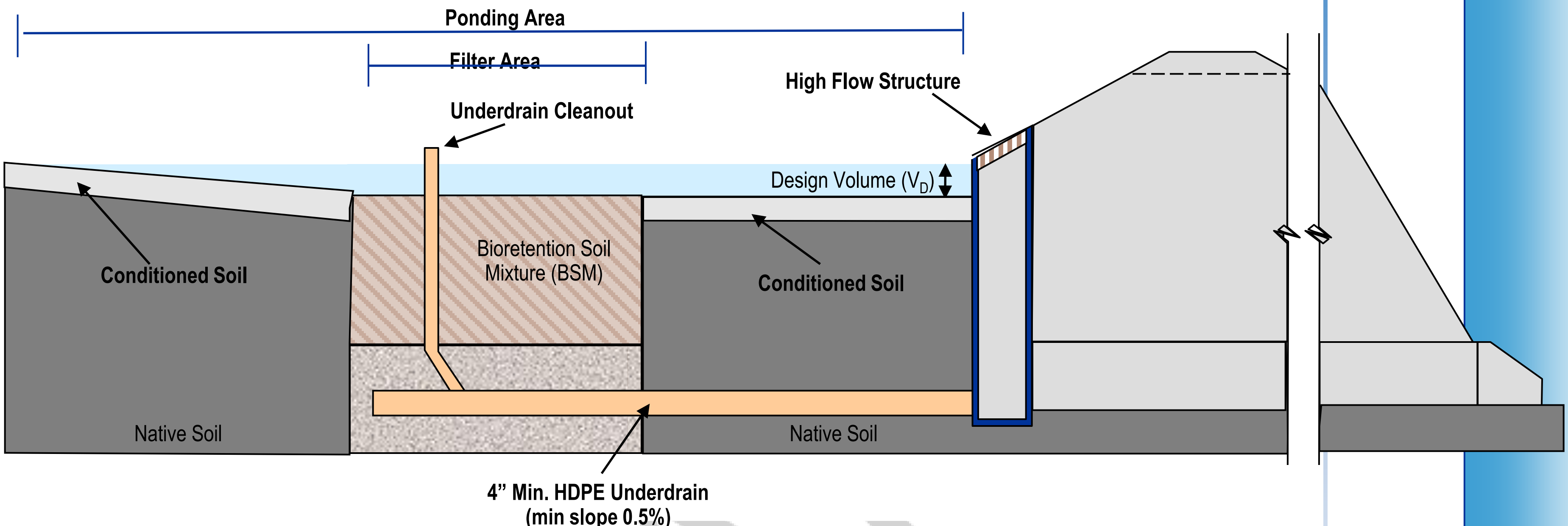
Design Considerations	
Location characteristics (Slope, Soil Type)	Slope: < 10%[1] Soil Type: A, B, C, D
Contributing drainage area	< 4 acres[1]
Design size	1-15% drainage area
	Minimum (W x L)[1]: 15 ft x 40 ft
Detention time for design volume treatment	1-3 days[1]
Median effluent concentrations[2]	TSS 4-6 mg/L, TP <0.1 – 0.35 mg/L, TN 0.6 – 2.5 mg/L, Cu 9-16 µg/L, E coli 58 – 90 cfu / 100 mL, Fecal coliform 2 – 290 MPN/100 mL
Implementation and Maintenance Considerations	
Potential for use with other BMPs	Works well with upstream source controls and filter strips and swales for pretreatment
Maintenance	High initially, lower with establishment of vegetation

Note: Median effluent concentrations apply to events with measured discharge.
[1]MARC, 2008
[2] Li and Davis, 2009

Design Requirements and Considerations

8.7.1.3 Design Requirements and Considerations

The procedure for designing a bioretention cell is outlined below. The design components are described in the order of construction starting with excavation for construction of the underdrain and continuing through bioretention media, planting soil, vegetation, ponding area, and high flow structures. Appendix E provides an example of a complete specification for a bioretention facility. A typical cross section is shown in Figure 8-18.



Overall Design Guidance

- Bioretention facilities should not be constructed until the entire drainage area is permanently stabilized against erosion or a pre-treatment practice is implemented or runoff is bypassed around the facility during construction and until the drainage area is stabilized. Heavy sediment loads to the cell will reduce infiltration rates and require reconstruction of the cell to restore its defined performance.

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Inspection and Maintenance

8.7.1.4 Inspection and Maintenance

Maintenance activities for bioretention areas include short-term and long-term maintenance tasks.

Short Term: Year 1 – Year 3

1. Water young plants and seedlings a minimum of weekly for the first three months. Watering may be required biweekly during the summer months (June through August) the first year.
2. Eliminate weeds using spot application of herbicide throughout the first year.
3. After rainfall equaling or exceeding 0.5 inches:
4. Redistribute mulch, remove trash, and inspect vegetation.
5. If sediment has accumulated, remove it and replace mulch and vegetation as needed.
6. Check for erosion inside and around the bioretention cell. Repair erosion damage if it occurs.
7. Repair or restore clogged high flow structures as needed.
8. Clean underdrain if clogged.
9. At one year after installation, inspect vegetation. Replace dead plants and remove invasive plant species.

Long-Term: Year 3 - later

1. In early spring, mow or trim vegetation to a height greater than 6 inches. Remove accumulated debris.
2. Inspect vegetation one to two times each year and remove weeds and invasive species.
3. Trim back or remove overgrown vegetation.
4. Repair or restore clogged high flow structures as needed.
5. Clean underdrain if clogged.

Inspection and Maintenance

8.7.1.5 Submittal Requirements

For review purposes prior to construction, the following minimum submittal requirements are recommended:

- Drainage area map, including drainage area to bioretention cell(s).
- Existing and proposed contour map of site (1-foot contours recommended). Additional spot elevations may be helpful.
- Geotechnical investigation of site (soil borings, water table location).
- In situ infiltration test of bioretention soil mixture demonstrating infiltration rate of 1 foot/day or higher.
- Stormwater plan/profile for site.
- Bioretention cell plan view and profile view. Components clearly labeled with dimensions.
- Hydrologic calculations (refer to Design Example). The designer should include necessary design calculations to show that flow is unconcentrated prior to entering the bioretention cell.
- Detail of any proposed underdrain and/or overflow structures with dimensions for construction. Include appropriate design calculations (refer to Design Example).
- Vegetation plan with schedule for installation and initial maintenance. Appropriate erosion control measures should be included.
- An as-built survey of the bioretention cell is recommended to confirm actual construction adheres to approved construction plans.
- Long-term inspection/maintenance plan.

Design Calculations

8.7.1.6 Design Calculations

A short summary of the design calculations is presented below. A detailed design example is outlined in Section 8.7.1.7.

Step 1 Determine the WQCV and V_D. The WQCV is based on the drainage area and capturing and controlling 0.5 inches of runoff as discussed in Section 8.3.1. The design volume is equal to the WQCV unless routing of impervious areas to pervious areas (i.e. cascading planes) occurs within the drainage area of the bioretention cell. The WQCV is based on 0.5 inches of runoff. If cascading planes are present, the design volume can be reduced because a portion of the WQCV from the impervious area is infiltrated. Section 8.3.3 provides additional guidance on calculating the design volume for drainage areas with cascading planes.

Step 2 Size the bioretention soil bed and surface depression The size of the bioretention soil bed and surface depression is based on the design volume and soil characteristics according to Equation 8-1 and 8-2. Equation 8-2 calculates a bioretention cell length based on the recommended 2:1 length to width ratio.

$$A_F = \frac{V_D \; x \; d_f}{k \; x \; t_f \; x \; (h_{avg} + d_f)} \qquad (8\text{-}1)$$

Where:

A_F	=	Filter bed surface area (acres)
V_D	=	Design Volume (acre-feet)
d_f	=	Planting soil bed depth (ft)
h_{avg}	=	Average ponding depth above plant in soil bed (feet) = (h_{max} / 2)
t_f	=	Time required for V_D to filter through soil (days) = 2 days
k	=	Coefficient of soil permeability (feet/day)

8.8 Lot Level/Homeowner Nonstructural Best Management Practices

- Types
  - Lawn Care and Landscape Maintenance
  - Trash and Pet Waste Reduction
  - Sweeping and Cleaning of Impervious Areas

Appendix

- Appendix A – Simple Method to Calculate Urban Stormwater Pollutant Loads and BMP Performance
  - EMCs by landuse including bacteria (Papillion Creek Partnernship)
  - Median Influent & Effluent Concentrations by BMP (International BMP Database)
- Appendix B – Example Stream Setback Fact Sheet
- Appendix C – Example Tree Preservation Ordinance
- Appendix D – Example Checklist for Preliminary & Concept Plan
- Appendix E – Derivation of Peak Flow Rate for WQ Storm
- Appendix F – Background Information on Cascading Planes
- Appendix G – Example Bioretention Facility Specification

Next Steps

- Completing the final revisions to the manual
  - Bioretention Garden
  - Soil Conditioning BMP
- Final manual by April 20, 2012
- Adapted by City Council in June 2012
- Developing standard design details (standard plates)
  - To be posted on City's website

QUESTIONS?

FOR MORE INFORMATION:

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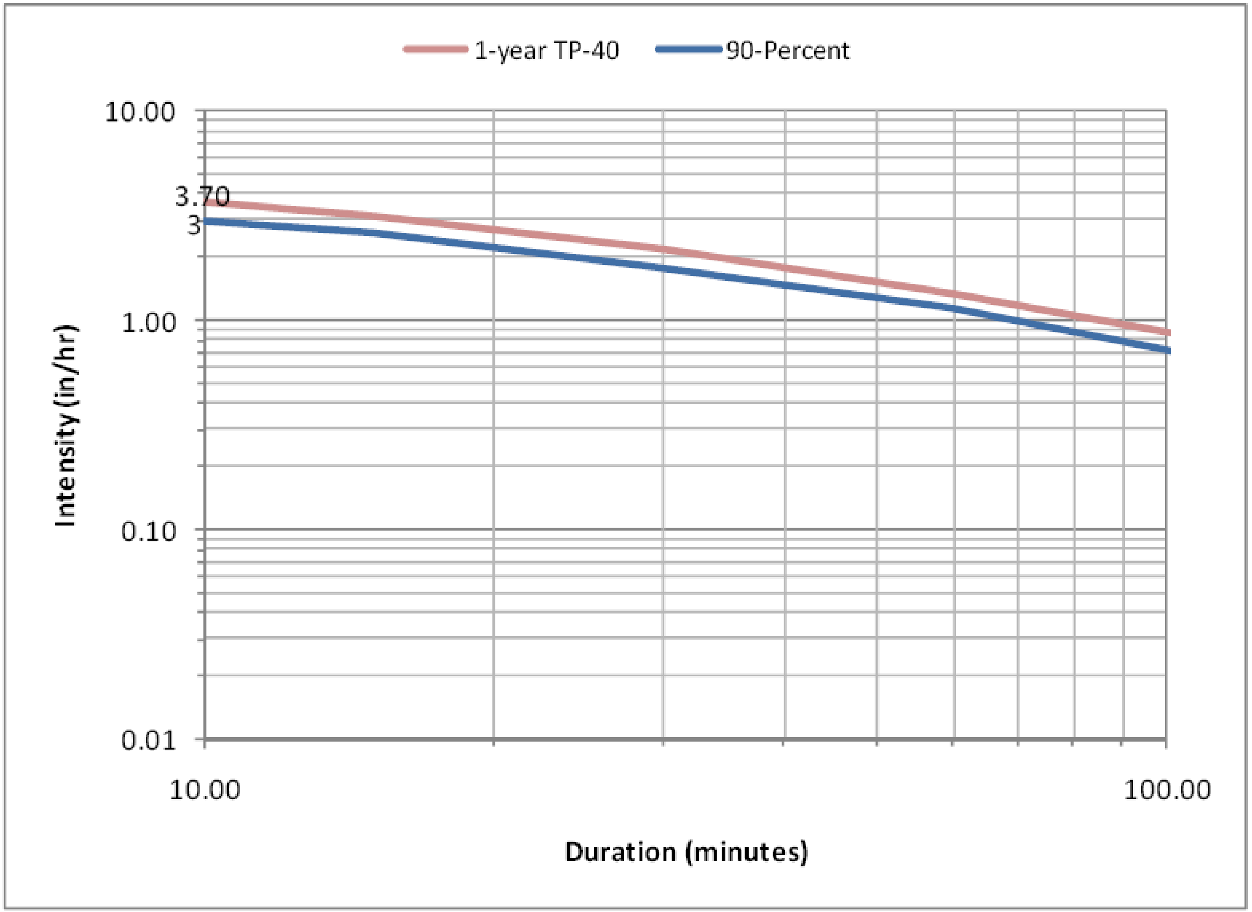

Figure 2 Intensity-Duration-Frequency (IDF) Curves for Omaha, Nebraska. (Adapted from TP-40).