Appendix

B

Appendix B: Storm Water Pollutant Control Hydrologic Calculations and Sizing Methods

Table of Contents:

Sizing worksheets in this Appendix are not intended to be used independently from the overall manual – rather they are intended to be used only as referenced in the manual. All PDP SWQMPs must include a completed Worksheet B-1 and other completed sizing worksheets from Appendix B, as applicable.

Worksheet B-1: Tabular Summary of DMAs

Tabular Summary of DMAs							Worksheet B-1		
DMA Unique Identifier	Area (acres)	Impervious Area (acres)	% Imp	HSG	Area Weighted Runoff Coefficient	DCV (Cubic feet)	Treated by (BMP ID)	Pollutant Control Type	Drains to (POC ID)
Summary of DMA Information (Must match Project description and SWQMP narrative)									
No. of DMAs	Total DMA Area (acres)	Total Impervious Area (acres)	% Impervious		Area Weighted Runoff Coefficient	DCV (Cubic feet)	Total Area Treated (acres)		No. of POCs

Where:
DMA = Drainage Management Area
HSG = Hydrologic Soil Group
BMP = Best Management Practice
Imp = Imperviousness
DCV= Design Capture Volume
POC = Point of Compliance
ID = identifier
No. = Number

B.1 DCV

DCV is defined as the volume of storm water runoff resulting from the 85th percentile, 24-hr storm event. The following hydrologic method shall be used to calculate the DCV

Equation B.1-1: Hydrologic Method for DCV

$$DCV = C \times d \times A \times 43,560\ sf/ac \times 1/12\ in/ft$$
$$DCV = 3,630 \times C \times d \times A$$

Where:

DCV = Design Capture Volume in cubic feet

C = Runoff factor (unitless); refer to section B.1.1

d = 85th percentile, 24-hr storm event rainfall depth (inches), refer to section B.1.3

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingles with project runoff and drains to the BMP. Refer to Chapter 3, Section 3.3.3 for additional guidance. Street redevelopment projects consult section 1.4.3.

DCV calculations shall be documented using **Worksheet B.2-1** (or equivalent).

B.1.1 Runoff Factor

Estimate the area weighted runoff factor for the tributary area to the BMP using runoff factor (from Table B.1-1) and area of each surface type in the tributary area and the following equation:

Equation B.1-2: Estimating Runoff Factor for Are

$$C = \frac{\sum C_x A_x}{\sum A_x}$$

Where:

C_x = Runoff factor for area X

A_x = Tributary area X (acres)

These runoff factors apply to areas receiving direct rainfall only. For conditions in which runoff is routed onto a surface from an adjacent surface, see Section B.2 for determining composite runoff factors for these areas.

Table B.1-1: Runoff factors for surfaces draining to BMPs – Pollutant Control BMPs

Surface	Runoff Factor
Roofs[1]	0.90
Concrete or Asphalt[1]	0.90
Unit Pavers (grouted)[1]	0.90
Decomposed Granite	0.30
Cobbles or Crushed Aggregate	0.30
Amended, Mulched Soils or Landscape[2]	0.10
Compacted Soil (e.g., unpaved parking)	0.30
Natural (A Soil)	0.10
Natural (B Soil)	0.14
Natural (C Soil)	0.23
Natural (D Soil)	0.30

1. Surface is considered impervious and could benefit from use of Site Design BMPs and adjustment of the runoff factor per Section B.2.1.
2. Surface shall be designed in accordance with SD-F (Amended soils) fact sheet in Appendix E

B.1.2 Offline BMPs

Diversion flow rates for offline BMPs shall be sized to convey the maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of every storm event. The following hydrologic method shall be used to calculate the diversion flow rate for off-line BMPs:

Equation B.1-3: Hydrologic Method

$$\boldsymbol{Q = C \times i \times A}$$

Where:

Q = Diversion flow rate in cubic feet per second

C = Runoff factor, area weighted estimate using Table B.1-1

i = Rainfall intensity of 0.2 in/hr

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drain to the BMP. Refer to Chapter 3, Section 3.3.3 for additional guidance. Street redevelopment projects also consult Section 1.4.3.

B.1.3 85th Percentile, 24-Hour Storm Event

The 85th percentile, 24-hour isopluvial map is provided as Figure B.1-1. The rainfall depth to estimate the DCV shall be determined using Figure B.1-1. The methodology used to develop this map is presented below:

B.1.3.1 Gage data and calculation of 85th percentile

The method of calculating the 85th percentile is to produce a list of values, order them from smallest to largest, and then pick the value that is 85 percent of the way through the list. Only values that are capable of producing run off are of interest for this purpose. Lacking a legislative definition of rainfall values capable of producing runoff, Flood Control staff in San Diego County have observed that the point at which significant runoff begins is rather subjective and is affected by land use type and soil moisture. In highly-urbanized areas, the soil has a high impermeability and runoff can begin with as little as 0.02" of rainfall. In rural areas, soil impermeability is significantly lower and even 0.30" of rain on dry soil will frequently not produce significant runoff. For this reason, San Diego County has chosen to use the more objective method of including all non-zero 24-hour rainfall totals when calculating the 85th percentile. To produce a statistically significant number, only stations with 30 years or greater of daily rainfall records are used.

B.1.3.2 Mapping the gage data

A collection of 56 precipitation gage points was developed with 85th percentile precipitation values based on multiple years of gage data. A raster surface (grid of cells with values) was interpolated from that set of points. The surface initially did not cover the County's entire jurisdiction. A total of 13 dummy points were added. Most of those were just outside the County boundary to enable the software to generate a surface that covered the entire County. A handful of points were added to enforce a plausible surface. In particular, one point was added in the desert east of Julian, to enforce a gradient from high precipitation in the mountains to low precipitation in the desert. Three points were added near the northern boundary of the County to adjust the surface to reflect the effect of elevation in areas lacking sufficient operating gages.

Several methods of interpolation were considered. The method chosen is named by Environmental Systems Research Institute as the Natural Neighbor technique. This method produces a surface that is highly empirical, with the value of the surface being a product of the values of the data points nearest each cell. It does not produce peaks or valleys of surface based on larger area trends, and is free of artifacts that appeared with other methods.

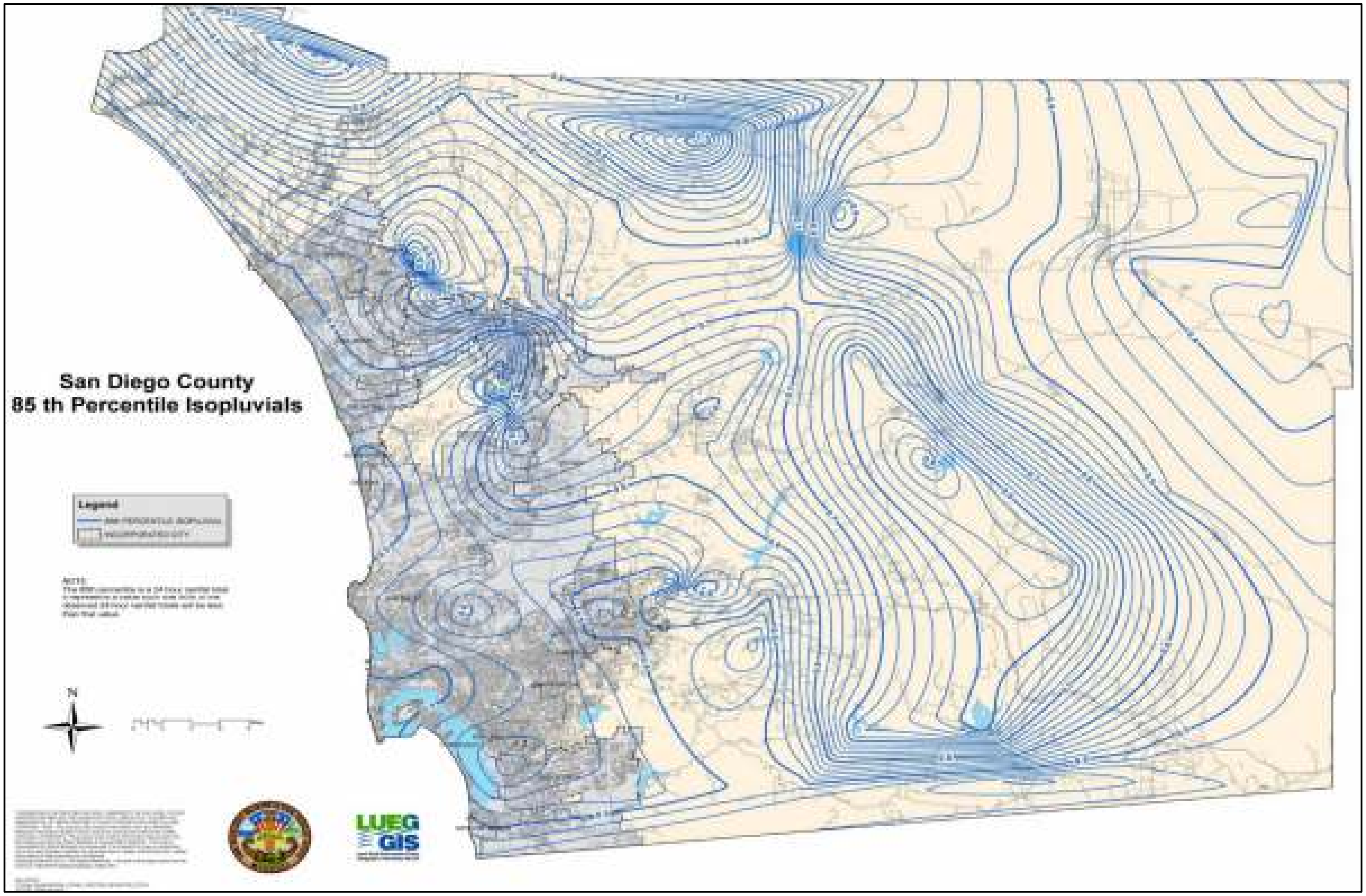


Figure B.1-1: 85th Percentile 24-hour Isopluvial Map

B.2 Adjustments to Account for Site Design BMPs

This section provides methods to adjust the DCV (for sizing pollutant control BMPs) as a result of implementing site design BMPs. The adjustments are provided by one of the following two methods:

- Adjustment to impervious runoff factor
- Adjustment to DCV

B.2.1 Adjustment to Impervious Runoff Factor

When one of the following site design BMPs is implemented the runoff factor of 0.9 for impervious surfaces identified in Table B.1-1 should be adjusted using the factors listed below and an adjusted area weighted runoff factor shall be estimated following guidance from **Section B.1.1** and used to calculate the DCV.

- SD-B Impervious area dispersion
- SD-C Green roofs
- SD-D Permeable pavement

B.2.1.1 Impervious area dispersion (SD-B)

Dispersion of impervious areas through pervious areas: The following adjustments are allowed to impervious runoff factors when dispersion is implemented in accordance with the SD-B fact sheet (**Appendix E**). In order to adjust the runoff factor, the pervious area shall have a minimum width of 10 feet and a maximum slope of 5% (exemption to this minimum width criterion is allowed when the contributing flow path length of the impervious area /pervious area width ≤ 2). Based on the ratio of **impervious area to pervious area** and the hydrologic soil group of the pervious area, the adjustment factor from Table B.2-1 shall be multiplied with the unadjusted runoff factor (Table B.1-1) of the impervious area to estimate the adjusted runoff factor for sizing pollutant control BMPs. The adjustment factors in Table B.2-1 are **only** valid for impervious surfaces that have an unadjusted runoff factor of 0.9.

Table B.2-1: Impervious area adjustment factors that accounts for dispersion

Pervious area hydrologic soil group	Ratio = Impervious area/Pervious area			
	<=1	2	3	4
A	0.00	0.00	0.23	0.36
B	0.00	0.27	0.42	0.53
C	0.34	0.56	0.67	0.74
D	0.86	0.93	0.97	1.00

Continuous simulation modeling in accordance with **Appendix G** is required to develop adjustment factors for surfaces that have an unadjusted runoff factor less than 0.9. Approval of adjustment factors for surfaces that have an unadjusted runoff factor less than 0.9 is at the discretion of the City Engineer.

The adjustment factors in Table B.2-1 were developed by performing continuous simulations in SWMM with default parameters from **Appendix G** and impervious to pervious area ratios of 1, 2, 3, and 4. When using adjustment factors from Table B.2-1:

- **Linear interpolation** shall be performed if the impervious to pervious area ratio of the site is in between one of ratios for which an adjustment factor was developed;
- Use adjustment factor for a ratio of 1 when the impervious to pervious area ratio is less than 1; and
- Adjustment factor from Table B.2-1 is not allowed when the impervious to pervious area ratio is greater than 4, when the pervious area is designed as a site design BMP. **Appendix B.5** has adjustment factors for scenarios when the impervious to pervious area ratio is greater than 4

Example B.2-1: DMA is comprised of one acre of impervious area that drains to a 0.4 acre hydrologic soil group B pervious area and then the pervious area drains to a BMP. Impervious area dispersion is implemented in the DMA in accordance with SD-5 factsheet. Estimate the adjusted runoff factor for the DMA.

- Baseline Runoff Factor per Table B.1-1 = [(1*0.9+0.4*0.14)/1.4] = 0.68.
- Impervious to Pervious Ratio = 1 acre impervious area/ 0.4 acre pervious area = 2.5; since the ratio is 2.5 adjustment can be claimed.
- From Table B.2-1 the adjustment factor for hydrologic soil group B and a ratio of 2 = 0.27; ratio of 3 = 0.42.
- Linear interpolated adjustment factor for a ratio of 2.5 = 0.27 + {[(0.42 -0.27)/(3-2)]*(2.5-2)} = 0.345.
- Adjusted runoff factor for the DMA = [(1*0.9*0.345+0.4*0.14)/1.4] = 0.26.
- Note only the runoff factor for impervious area is adjusted, there is no change made to the pervious area.

B.2.1.2 Green Roofs

When green roofs are implemented in accordance with the **SD-C factsheet** the green roof footprint shall be assigned a runoff factor of 0.10 for adjusted runoff factor calculations when the green roof receives runon from other areas within the project footprint (i.e., multi-level or partial green roof).

If a DMA only contains a green roof that is designed in accordance with SD-6A fact sheet, then it can be considered as a self-retaining DMA that meets the storm water pollutant control obligations and no additional DCV calculations are necessary for this DMA.

B.2.1.3 Permeable Pavement

When a permeable pavement is implemented in accordance with the **SD-D factsheet** and it **does not have an impermeable liner** and has storage greater than the 85th percentile depth below the underdrain, if an underdrain is present, then the footprint of the permeable pavement shall be assigned a runoff factor of 0.10 for adjusted runoff factor calculations. The slope of the permeable pavements designed as site BMPs must be less than or equal to 5%.

Permeable Pavement can also be designed as a structural BMP to treat run on from adjacent areas. Refer to INF-3 factsheet and **Appendix E and Appendix B.4** for additional guidance.

B.2.2 Adjustment to DCV

When the following site design BMPs are implemented the anticipated volume reduction from these BMPs shall be deducted from the DCV to estimate the volume for which the downstream structural BMP should be sized for:

- SD-A: Trees
- SD-E Rain barrels

B.2.2.1 Trees

Applicants are allowed to take credit for installing new trees using Table B.2-2 or Equation B.2-1 as applicable, when trees are implemented in accordance with SD-A fact sheet and meet the following criteria:

- Total tree credit volume is less than or equal to 0.25DCV of the project footprint and
- Single tree credit volume is less than or equal to 400 ft3

Credit for trees that do not meet the above criteria shall be based on the criteria for sizing the tree as a storm water pollutant control BMP in SD-A fact sheet. These credit calculations are based on an assumption that each tree and associated trench or box is considered a single BMP, with calculations based on the media storage volume and contributing area.

Table B.2-2 was developed assuming that the entire tributary area is impervious (use Equation B.2-1 if there are different types of surfaces in the contributing area) and an 85th percentile 24-hour rainfall depth of 0.5 inches. The procedure for estimating the tree credit volume using Table B.2-2:

- Delineate the tributary area to the tree and use this tributary area to determine the tree credit volume using Table B.2-2. Use linear interpolation if the tributary area is in between the areas listed in Table B.2-2. When the contributing area is greater than 10,667 ft2 this simplified method is not allowed.
- Using the amount of soil volume installed to determine the credit using Table B.2-2. Use linear interpolation if the soil volume is in between the values listed in Table B.2-2. When the soil volume is greater than 1,333 ft3 this simplified method is not allowed.
- Use the smaller tree credit volume of the two estimates.

Table B.2-2: Allowable Reduction in DCV

Tree Credit Volume (ft^3/tree)[1]	Contributing Area (ft^2)	Soil Volume (ft^3)
10	267	33
50	1,333	167
100	2,667	333
150	4,000	500
200	5,333	667
300	8,000	1,000
400	10,667	1,333

Note: [1]If an underdrain installed only 1/3rd of the tree credit volume shown in Table B.2-2 is allowed.

Applicant can also estimate the tree credit volume using Equation B.2-1.

Equation B.2-1: Tree Credit Volume

$$TCV = Minimum\ (SV \times 0.3,\ 3{,}630 \times d \times C \times A);\ \textit{With no underdrains installed}$$

$$TCV = Minimum\ (SV \times 0.1,\ 3{,}630 \times d \times C \times A);\ \textit{When an underdrains installed}$$

Where

TCV = Tree credit volume (ft^3), maximum of 400 ft^3 for one tree & not more than 0.25*DCV from the project footprint for all trees proposed as site design BMPs

SV = Soil volume installed with the tree (ft3)

d = 85th percentile 24-hr storm depth (inches) from Figure B.1-1

C = Area weighted runoff factor (calculate using Appendix B.1.1 and B.2.1)

A = Area tributary to the tree (acres)

B.2.2.2 Rain Barrels

Rain barrels are containers that can capture rooftop runoff and store it for future use. Credit can be taken for the full rain barrel volume when each barrel volume is smaller than 100 gallons, implemented per **SD-E fact sheet** and meet the following criteria:

- Total rain barrel volume is less than 0.25 DCV **and**
- Landscape areas are greater than 30 percent of the project footprint.

Credit for harvest and use systems that do not meet the above criteria shall be based on the criteria in **Appendix B.3** and HU-1 fact sheet **Appendix E**.

Worksheet B.2-1 DCV

Design Capture Volume		Worksheet B.2-1		
1	85th percentile 24-hr storm depth from Figure B.1-1	d=		inches
2	Area tributary to BMP (s)	A=		acres
3	Area weighted runoff factor (estimate using Appendix B.1.1 and B.2.1)	C=		unitless
4	Tree well volume Note: In the SWQMP list the number of trees, size of each tree, amount of soil volume installed for each tree, contributing area to each tree and the inlet opening dimension for each tree.	TCV=		cubic-feet
5	Rain barrels Credit volume Note: In the SWQMP list the number of rain barrels, size of each rain barrel and the use of the captured storm water runoff.	RCV=		cubic-feet
6	Calculate DCV = (3630 x C x d x A) – TCV - RCV	DCV=		cubic-feet

B.3 Harvest and Use BMPs

The purpose of this section is to provide guidance for evaluating feasibility of harvest and use BMPs, calculating harvested water demand and sizing harvest and use BMPs.

B.3.1 Planning Level Harvest and Use Feasibility

Harvest and use feasibility should be evaluated at the scale of the entire project, and not limited to a single DMA. For the purpose of initial feasibility screening, it is assumed that harvested water collected from one DMA could be used within another. Types of non-potable water demand that may apply within a project include:

- Toilet and urinal flushing
- Irrigation
- Vehicle washing
- Evaporative cooling
- Dilution water for recycled water systems
- Industrial processes
- Other non-potable uses

Form I-7: Worksheet B.3-1 provides a screening process for determining the preliminary feasibility for harvest and use BMPs. This worksheet should be completed for the overall project.

Worksheet B.3-1: Harvest and Use Feasibility Screening

<table>
<tr><th colspan="2">Harvest and Use Feasibility Screening</th><th>Worsksheet B.3-1</th></tr>
<tr><td colspan="3">1. Is there a demand for harvested water (check all that apply) at the project site that is reliably present during the wet season?
☐ Toilet and urinal flushing
☐ Landscape irrigation
☐ Other:______________</td></tr>
<tr><td colspan="3">2. If there is a demand; estimate the anticipated average wet season demand over a period of 36 hours. Guidance for planning level demand calculations for toilet/urinal flushing and landscape irrigation is provided in Section B.3.2.
[Provide a summary of calculations here]</td></tr>
<tr><td colspan="3">3. Calculate the DCV using worksheet B-2.1.
[Provide a results here]</td></tr>
<tr><td>3a. Is the 36-hour demand greater than or equal to the DCV?
Yes / No ⇨
⇩</td><td>3b. Is the 36-hour demand greater than 0.25DCV but less than the full DCV?
Yes / No ⇨
⇩</td><td>3c. Is the 36-hour demand less than 0.25DCV?
Yes
⇩</td></tr>
<tr><td>Harvest and use appears to be feasible. Conduct more detailed evaluation and sizing calculations to confirm that DCV can be used at an adequate rate to meet drawdown criteria.</td><td>Harvest and use may be feasible. Conduct more detailed evaluation and sizing calculations to determine feasibility. Harvest and use may only be able to be used for a portion of the site, or (optionally) the storage may need to be upsized to meet long term capture targets while draining in longer than 36 hours.</td><td>Harvest and use is considered to be infeasible.</td></tr>
</table>

Note: 36-hour demand calculations are for feasibility analysis only. Once feasibility analysis is complete the applicant may be allowed to use a different drawdown time provided they meet the 80% of average annual (long term) runoff volume performance standard.

B.3.2 Harvested Water Demand Calculation

The following sections provide technical references and guidance for estimating the harvested water demand of a project. These references are intended to be used for the planning phase of a project for feasibility screening purposes.

B.3.2.1 Toilet and Urinal Flushing Demand Calculations

The following guidelines should be followed for computing harvested water demand from toilet and urinal flushing:

- If reclaimed water is planned for use for toilet and urinal flushing, then the demand for harvested storm water is equivalent to the total demand minus the reclaimed water supplied, and should be reduced by the amount of reclaimed water that is available during the wet season.
- Demand calculations for toilet and urinal flushing should be based on the average rate of use during the wet season for a typical year.
- Demand calculations should include changes in occupancy over weekends and around holidays and changes in attendance/enrollment over school vacation periods.
- For facilities with generally high demand, but periodic shut downs (e.g., for vacations, maintenance, or other reasons), a project specific analysis should be conducted to determine whether the long term storm water capture performance of the system can be maintained despite shut downs.
- Such an analysis should consider the statistical distributions of precipitation and demand, most importantly the relationship of demand to the wet seasons of the year.

Table B.3-1 provides planning level demand estimates for toilet and urinal flushing per resident, or employee, for a variety of project types. The per capita use per day is based on daily employee or resident usage. For non-residential types of development, the “visitor factor” and “student factor” (for schools) should be multiplied by the employee use to account for toilet and urinal usage for non-employees using facilities.

Note: Table B.3-1 provides a demand estimate for 24 hours, for feasibility analysis this estimate must be multiplied by 1.5 to calculate the 36-hour demand.

Table B.3-1: Toilet and Urinal Water Usage per Resident or Employee

Land Use Type	Toilet User Unit of Normalization	Per Capita Use per Day		Visitor Factor[4]	Water Efficiency Factor	Total Use per Resident or Employee
		Toilet Flushing[1,2]	Urinals[3]			
Residential	Resident	18.5	NA	NA	0.5	9.3
Office	Employee (non-visitor)	9.0	2.27	1.1	0.5	7 (avg)
Retail	Employee (non-visitor)	9.0	2.11	1.4	0.5	7 (avg)
Schools	Employee (non-student)	6.7	3.5	6.4	0.5	33
Various Industrial Uses (excludes process water)	Employee (non-visitor)	9.0	2	1	0.5	5.5

[1] Based on American Waterworks Association Research Foundation,1999. Residential End Uses of Water. Denver, CO: AWWARF

[2] Based on use of 3.45 gallons per flush and average number of per employee flushes per subsector, Table D-1 for MWD (Pacific Institute, 2003)

[3] Based on use of 1.6 gallons per flush, Table D-4 and average number of per employee flushes per subsector, Appendix D (Pacific Institute, 2003)

[4] Multiplied by the demand for toilet and urinal flushing for the project to account for visitors. Based on proportion of annual use allocated to visitors and others (includes students for schools; about 5 students per employee) for each subsector in Table D-1 and D-4 (Pacific Institute, 2003)

[5] Accounts for requirements to use ultra low flush toilets in new development projects; assumed that requirements will reduce toilet and urinal flushing demand by half on average compared to literature estimates. Ultra low flush toilets are required in all new construction in California as of January 1, 1992. Ultra low flush toilets must use no more than 1.6 gallons per flush and Ultra low flush urinals must use no more than 1 gallon per flush. Note: If zero flush urinals are being used, adjust accordingly.

B.3.2.2 General Requirements for Irrigation Demand Calculations

The following guidelines should be followed for computing harvested water demand from landscape irrigation:

- If reclaimed water is planned for use for landscape irrigation, then the demand for harvested storm water should be reduced by the amount of reclaimed water that is available during the wet season.
- Irrigation rates should be based on the irrigation demand exerted by the types of landscaping that are proposed for the project, with consideration for water conservation requirements.
- Irrigation rates should be estimated to reflect the average wet season rates (defined as October through April) accounting for the effect of storm events in offsetting harvested water demand. In the absence of a detailed demand study, it should be assumed that irrigation demand is not present during days with greater than 0.1 inches of rain and the subsequent 3-day period. This irrigation shutdown period is consistent with standard practice in land application of wastewater and is applicable to storm water to prevent irrigation from resulting in dry weather runoff. Based on a statistical analysis of San Diego County rainfall patterns, approximately 30 percent of wet season days would not have a demand for irrigation.
- If land application of storm water is proposed (irrigation in excess of agronomic demand), then this BMP must be considered to be an infiltration BMP and feasibility screening for infiltration must be conducted. In addition, it must be demonstrated that land application would not result in greater quantities of runoff as a result of saturated soils at the beginning of storm events. Agronomic demand refers to the rate at which plants use water.

The following sections describe methods that should be used to calculate harvested water irrigation demand. While these methods are simplified, they provide a reasonable estimate of potential harvested water demand that is appropriate for feasibility analysis and project planning. These methods may be replaced by a more rigorous project-specific analysis that meets the intent of the criteria above.

B.3.2.2.1 Demand Calculation Method

This method is based on the San Diego Municipal Code Land Development Code Landscape Standards Appendix E which includes a formula for estimating a project's annual estimated total water use based on reference evaporation, plant factor, and irrigation efficiency.

For the purpose of calculating harvested water irrigation demand applicable to the sizing of harvest and use systems, the estimated total water use has been modified to reflect typical wet-season irrigation demand. This method assumes that the wet season is defined as October through April. This method further assumes that no irrigation water will be applied during days with precipitation totals greater than 0.1 inches or within the 3 days following such an event. Based on these assumptions and an analysis of Lake Wohlford, Lindbergh and Oceanside precipitation patterns, irrigation would not be applied during approximately 30 percent of days from October through April.

Equation B.3-1 is used to calculate the Modified Estimated Total Water Usage:

Equation B.3-1 Modified Estimated Total Water Usage

$$\text{Modified ETWU} = ET_{oWet} \times [[\Sigma(PF \times HA)/IE] + SLA] \times 0.015$$

Where:

Modified ETWU	=	Estimated daily average water usage during wet season
ET_{oWet}	=	Average reference evapotranspiration from November through April (use 2.7 inches per month, using CIMS Zone 4 from Table G.1-1)
PF	=	Plant Factor
HA	=	Hydrozone Area (sq-ft); A section or zone of the landscaped area having plants with similar water needs.
Σ(PF x HA)	=	The sum of PF x HA for each individual Hydrozone (accounts for different landscaping zones).
IE	=	Irrigation Efficiency (assume 90 percent for demand calculations)
SLA	=	Special Landscape Area (sq-ft); Areas used for active and passive recreation areas, areas solely dedicated to the production of fruits and vegetables, and areas irrigated with reclaimed water

Note: In this equation, the coefficient (0.015) accounts for unit conversions and shut down of irrigation during and for the three days following a significant precipitation event:

0.015 = (1 mo/30 days)×(1 ft/12 in)×(7.48 gal/cu-ft)×(approximately 7 out of 10 days with irrigation demand from October through April)

Table B.3-2: Planning Level Plant Factor Recommendations

Plant Water Use	Plant Factor	Also Includes
Low	< 0.1 – 0.2	Artificial Turf
Moderate	0.3 – 0.7	
High	0.8 and greater	Water features
Special Landscape Area	1.0	

B.3.2.2.2 Planning Level Irrigation Demands

To simplify the planning process, the method described above has been used to develop daily average wet season demands for a one-acre irrigated area based on the plant/landscape type. These demand estimates can be used to calculate the drawdown of harvest and use systems for the purpose of LID BMP sizing calculations.

Table B.3-3: Planning Level Irrigation Demand by Plant Factor and Landscape Type

General Landscape Type	36-Hour Planning Level Irrigation Demand (gallons per irrigated acre per 36 hour period)
Hydrozone – Low Plant Water Use	390
Hydrozone – Moderate Plant Water Use	1,470
Hydrozone – High Plant Water Use	2,640
Special Landscape Area	2,640

B.3.2.3 Calculating Other Harvested Water Demands

Calculations of other harvested water demands should be based on the knowledge of land uses, industrial processes, and other factors that are project-specific. Demand should be calculated based on the following guidelines:

- Demand calculations should represent actual demand that is anticipated during the wet season (October through April).
- Sources of demand should only be included if they are reliably and consistently present during the wet season.
- Where demands are substantial but irregular, a more detailed analysis should be conducted based on a statistical analysis of anticipated demand and precipitation patterns.

B.3.3 Sizing Harvest and Use BMPs

Sizing calculations shall demonstrate that one of two equivalent performance standards is met:

1. Harvest and use BMPs are sized to drain the tank in 36 hours following the end of rainfall. The size of the BMP is dependent on the demand (Section B.3.2) at the site.
2. Harvest and use BMP is designed to capture at least 80 percent of average annual (long term) runoff volume.

It is rare cisterns can be sized to capture the full DCV and use this volume in 36 hours. So, when using **Form I-7: Worksheet B.3-1** if it is determined that harvest and use BMP is feasible then the BMP should be sized to the estimated 36-hour demand and the remaining DCV must be mitigated using other BMPs.

B.4 Infiltration BMPs

Sizing calculations shall demonstrate that one of two equivalent performance standards is met:

1. The BMP or series of BMPs captures the DCV and infiltrates this volume fully within 36 hours following the end of precipitation. This can be demonstrated through the Simple Method (**Section B.4.1**).
2. The BMP or series of BMPs infiltrates at least 80 percent of average annual (long term) runoff volume. This can be demonstrated using the percent capture method (**Section B.4.2**), through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in **Appendix G**, as acceptable to the City Engineer. This method is **<u>not</u>** applicable for sizing biofiltration BMPs.

The methods to show compliance with these standards are provided in the following sections.

B.4.1 Simple Method

<u>Stepwise Instructions:</u>

1. Compute DCV using Worksheet B.4-1
2. Estimate design infiltration rate using Worksheet D.5-1
3. Design BMP(s) to ensure that the DCV is fully retained (i.e., no surface discharge during the design event) and the stored effective depth draws down in no longer than 36 hours.

Worksheet B.4-1: Simple Sizing Method for Infiltration BMPs

Simple Sizing Method for Infiltration BMPs		Worksheet B.4-1		
1	DCV (Worksheet B-2.1)	DCV=		cubic-feet
2	Estimated design infiltration rate (Worksheet D.5-1)	Kdesign=		in/hr
3	Available BMP surface area	ABMP=		sq-ft
4	Average effective depth in the BMP footprint (DCV/ABMP)	Davg=		feet
5	Drawdown time, T (Davg *12/Kdesign)	T=		hours
6	Provide alternative calculation of drawdown time, if needed.			
7	Provide calculations for effective depth provided in the BMP: Effective Depth = Surface ponding (below the overflow elevation) + gravel storage thickness x gravel porosity (0.4)			

Notes:

1. Drawdown time must be less than 36 hours. This criterion was set to achieve average annual capture of 80% to account for back to back storms (See rationale in Section B.4.3). In order to use a different drawdown time, BMPs should be sized using the percent capture method (Section B.4.2).
2. The average effective depth calculation should account for any aggregate/media in the BMP. For example, 4 feet of stone at a porosity of 0.4 would equate to 1.6 feet of effective depth.
3. This method may overestimate drawdown time for BMPs that drain through both the bottom and walls of the system. BMP specific calculations of drawdown time may be provided that account for BMP-specific geometry.

B.4.2 Percent Capture Method

This section describes the recommended method of sizing volume-based BMPs to achieve the 80 percent capture performance criterion. This method has a number of potential applications for sizing BMPs, including:

- Use this method when a BMP can draw down in less than 36 hours and it is desired to demonstrate that 80 percent capture can be achieved using a BMP volume smaller than the DCV.
- Use this method to determine how much volume (greater than the DCV) must be provided to achieve 80 percent capture when the drawdown time of the BMP exceeds 36 hours.
- Use this method to determine how much volume should be provided to achieve 80 percent capture when upstream BMP(s) have achieved some capture, but have not achieved 80 percent capture.

By nature, the percent capture method is an iterative process that requires some initial assumptions about BMP design parameters and subsequent confirmation that these assumptions are valid. For example, sizing calculations depend on the assumed drawdown time, which depends on BMP depth, which may in turn need to be adjusted to provide the required volume within the allowable footprint. In general, the selection of reasonable BMP design parameters in the first iteration will result in minimal required additional iterations. **Figure B.4-1** presents the nomograph for use in sizing retention BMPs in San Diego County.

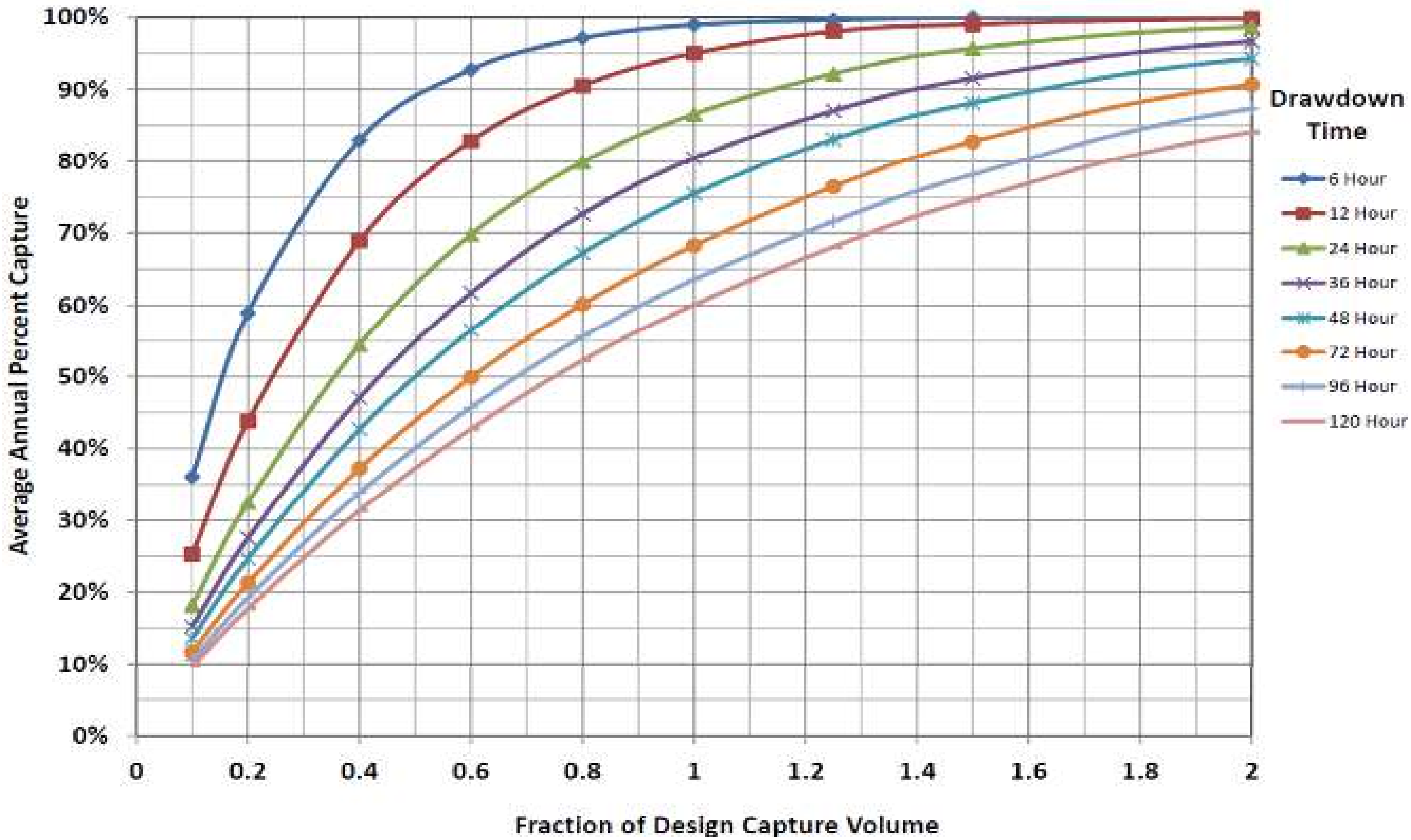


Figure B.4-1: Percent Capture Nomograph

B.4.2.1 Stepwise Instructions for sizing a single BMP:

1. Estimate the drawdown time of the proposed BMP by estimating the design infiltration rate (**Form I-9: Worksheet D.5-1**) and accounting for BMP dimensions/geometry. See the applicable BMP Fact Sheet for specific guidance on how to convert BMP geometry to estimated drawdown time.
2. Using the estimated drawdown time and the nomograph from Figure B.4-1 locate where the line corresponding to the estimated drawdown time intersects with 80 percent capture. Pivot to the X axis and read the fraction of the DCV that needs to be provided in the BMP to achieve this level of capture.
3. Calculate the DCV using **Worksheet B.2-1**.
4. Multiply the result of Step 2 by the DCV (Step 3). This is the required BMP design volume.
5. Design the BMP to retain the required volume, and confirm that the drawdown time is no more than 25 percent greater than estimated in Step 1. If the computed drawdown time is greater than 125 percent of the estimated drawdown, then return to Step 1 and revise the initial drawdown time assumption.

See the respective BMP facts sheets for BMP-specific instructions for the calculation of volume and drawdown time. The above method can also be used to size and/or evaluate the performance of other retention BMPs (evapotranspiration, harvest and use) that have a drawdown rate that can be approximated as constant throughout the year or over the wet season. In order to use this method for other retention BMPs, drawdown time in Step 1 will need to be evaluated using an applicable method for the type of BMP selected. After completing Step 1 continue to Step 2 listed above.

Example B.4.2.1 Percent Capture Method for Sizing a Single BMP:

Given:

- Estimated drawdown time: 72 Hours
- DCV: 3000 ft^3

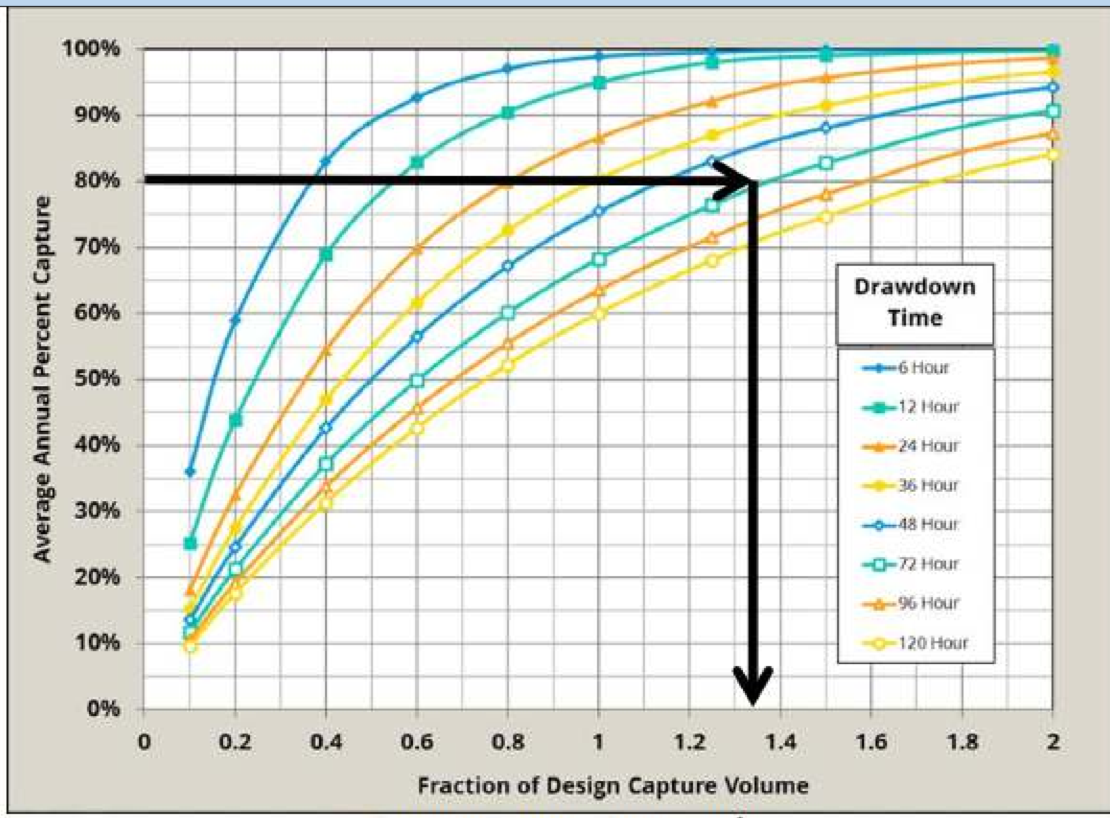
Required:

- Determine the volume required to achieve 80 percent capture.

Solution:

1. Estimated drawdown time = 72 Hours
2. Fraction of DCV required = 1.35
3. DCV = 3000 ft^3 (Given for this example; To be estimated using Worksheet B.2-1)
4. Required BMP volume = 1.35 x 3000 = 4050 ft^3
5. Design BMP and confirm drawdown Time is $\leq$ 90 Hours (72 Hours +25%)

Graphical Operations Supporting Solution:



Percent Capture Nomograph

B.4.2.2 Stepwise Instructions for sizing BMPs in series:

For projects where BMPs in series have to be implemented to meet the performance standard the following stepwise procedure shall be used to size the downstream BMP to achieve the 80 percent capture performance criterion:

1. Using the upstream BMP parameters (volume and drawdown time) estimate the average annual capture efficiency achieved by the upstream BMP using the nomograph.
2. Estimate the drawdown time of the proposed downstream BMP by estimating the design infiltration rate (Worksheet D.5-1) and accounting for BMP dimensions/geometry. See the applicable BMP Fact Sheet for specific guidance on how to convert BMP geometry to estimated drawdown time. Use the nomograph and locate where the line corresponding to the estimated drawdown time intersects with 80 percent capture. Pivot to the horizontal axis and read the fraction of the DCV that needs to be provided in the BMP. This is referred to as X1.
3. Trace a horizontal line on the nomograph using the capture efficiency of the upstream BMP estimated in Step 1. Find where the line traced intersects with the drawdown time of the downstream BMP (Step 2). Pivot and read down to the horizontal axis to yield the fraction of the DCV already provided by the upstream BMP. This is referred to as X2.
4. Subtract X2 (Step 3) from X1 (Step 2) to determine the fraction of the design volume that must be provided in the downstream BMP to achieve 80 percent capture to meet the performance standard.
5. Multiply the result of Step 4 by the DCV. This is the required downstream BMP design volume.
6. Design the BMP to retain the required volume, and confirm that the drawdown time is no more than 25 percent greater than estimated in Step 2. If the computed drawdown time is greater than 125 percent of the estimated drawdown, then return to Step 2 and revise the initial drawdown time assumption.

See the respective BMP facts sheets for BMP-specific instructions for the calculation of volume and drawdown time.

Example B.4.2.2 Percent Capture Method for Sizing BMPs in Series:

Given:

- Estimated drawdown time for downstream BMP: 72 Hours
- DCV for the area draining to the BMP: 3000 ft3
- Upstream BMP volume: 900 ft3
- Upstream BMP drawdown time: 24 Hours

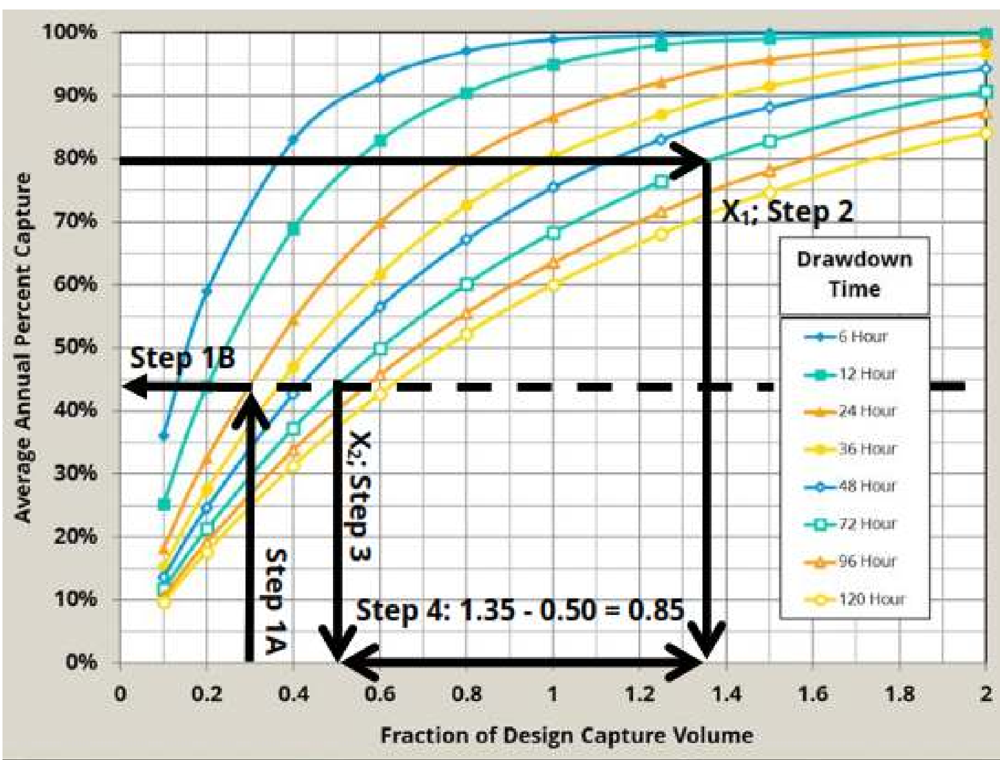
Required:

- Determine the volume required in the downstream BMP to achieve 80 percent capture.

Solution:

1. Step 1A: Upstream BMP Capture Ratio = 900/3000 = 0.3; Step 1B: Average annual capture efficiency achieved by upstream BMP = 44%
2. Downstream BMP drawdown = 72 hours; Fraction of DCV required to achieve 80% capture = 1.35
3. Locate intersection of design capture efficiency and drawdown time for upstream BMP (See Graph); Fraction of DCV already provided (X2) = 0.50 (See Graph)
4. Fraction of DCV Required by downstream BMP = 1.35-0.50 = 0.85
5. DCV (given) = 3000 ft3 ; Required downstream BMP volume = 3000 ft3 x 0.85 = 2,550 ft3
6. Design BMP and confirm drawdown Time is < 90 Hours (72 Hours +25%)

Graphical Operations Supporting Solution:



Percent Capture Nomograph

B.4.3 Technical Basis for Equivalent Sizing Methods

Storm water BMPs can be conceptualized as having a storage volume and a treatment rate, in various proportions. Both are important in the long-term performance of the BMP under a range of actual storm patterns, depths, and inter-event times. Long-term performance is measured by the operation of a BMP over the course of multiple years, and provides a more complete metric than the performance of a BMP during a single event, which does not take into account antecedent conditions, including multiple storms arriving in short timeframes. A BMP that draws down more quickly would be expected to capture a greater fraction of overall runoff (i.e., long-term runoff) than an identically sized BMP that draws down more slowly. This is because storage is made available more quickly, so subsequent storms are more likely to be captured by the BMP. In contrast a BMP with a long drawdown time would stay mostly full, after initial filling, during periods of sequential storms. The volume in the BMP that draws down more quickly is more "valuable" in terms of long term performance than the volume in the one that draws down more slowly. The MS4 permit definition of the DCV does not specify a drawdown time, therefore the definition is not a complete indicator of a BMP's level of performance. An accompanying performance-based expression of the BMP sizing standard is essential to ensure uniformity of performance across a broad range of BMPs and helps prevents BMP designs from being used that would not be effective.

An evaluation of the relationships between BMP design parameters and expected long term capture efficiency has been conducted to address the needs identified above. Relationships have been developed through a simplified continuous simulation analysis of precipitation, runoff, and routing, that relate BMP design volume and storage recovery rate (i.e., drawdown time) to an estimated long term level of performance using United States Environmental Protection Agency (USEPA) SWMM and parameters listed in Appendix G for Lake Wohlford, Lindbergh, and Oceanside rain gages. Comparison of the relationships developed using the three gages indicated that the differences in relative capture estimates are within the uncertainties in factors used to develop the relationships. For example, the estimated average annual capture for the BMP sized for the DCV and 36 hour drawdown using Lake Wohlford, Lindbergh, and Oceanside are 80%, 76% and 83% respectively. In an effort to reduce the number of curves that are made available, relationships developed using Lake Wohlford are included in this manual for use in the whole San Diego County region.

Figure B.4-1 demonstrated that a BMP sized for the runoff volume from the 85th percentile, 24-hour storm event (i.e., the DCV), which draws down in 36 hours is capable of managing approximately 80 percent of the average annual. There is long precedent for 80 percent capture of average annual runoff as approximately the point at which larger BMPs provide decreasing capture efficiency benefit (also known as the "knee of the curve") for BMP sizing. The characteristic shape of the plot of capture efficiency versus storage volume in Figure B.4-1 illustrates this concept.

As such, this equivalency (between DCV draw down in 36-hours and 80 percent capture) has been utilized to provide a common currency between volume-based BMPs with a wide range of drawdown rates. This approach allows flexibility in the design of BMPs while ensuring consistent performance within the City.

B.5 Biofiltration BMPs

Biofiltration BMPs shall be sized by one of the following sizing methods:

- **Option 1:** Treat 1.5 times the portion of the DCV not reliably retained onsite, **OR**
- **Option 2:** Treat 1.0 times the portion of the DCV not reliably retained onsite; and additionally, check that the system has a total static (i.e., non-routed) storage volume, including pore spaces and pre-filter detention volume, equal to at least 0.75 times the portion of the DCV not reliably retained onsite.

When using sizing Option 1 a routing period of 6 hours is allowed. The routing period was estimated based on 50th percentile storm duration for storms similar to 85th percentile rainfall depth. It was estimated based on inspection of continuous rainfall data from Lake Wohlford, Lindbergh and Oceanside rain gages.

The MS4 Permit specifies (Footnote 29) that the hydraulic loading rate and other biofiltration design criteria must be selected such that storm water retention and pollutant removal are maximized. To meet this provision, this manual includes specific criteria for design of biofiltration BMPs. Among other criteria, a minimum footprint sizing factor of 3 percent (BMP footprint area as percent of contributing area times adjusted runoff factor) and a volume retention performance standard (Figure B.5-2) based on the reliable infiltration rate at the site (i.e. measured infiltration rate/factor of safety of 2) is specified. **Appendix B.5.3 provides** the technical rationale for the 3 percent minimum sizing factor and the volume retention performance standard.

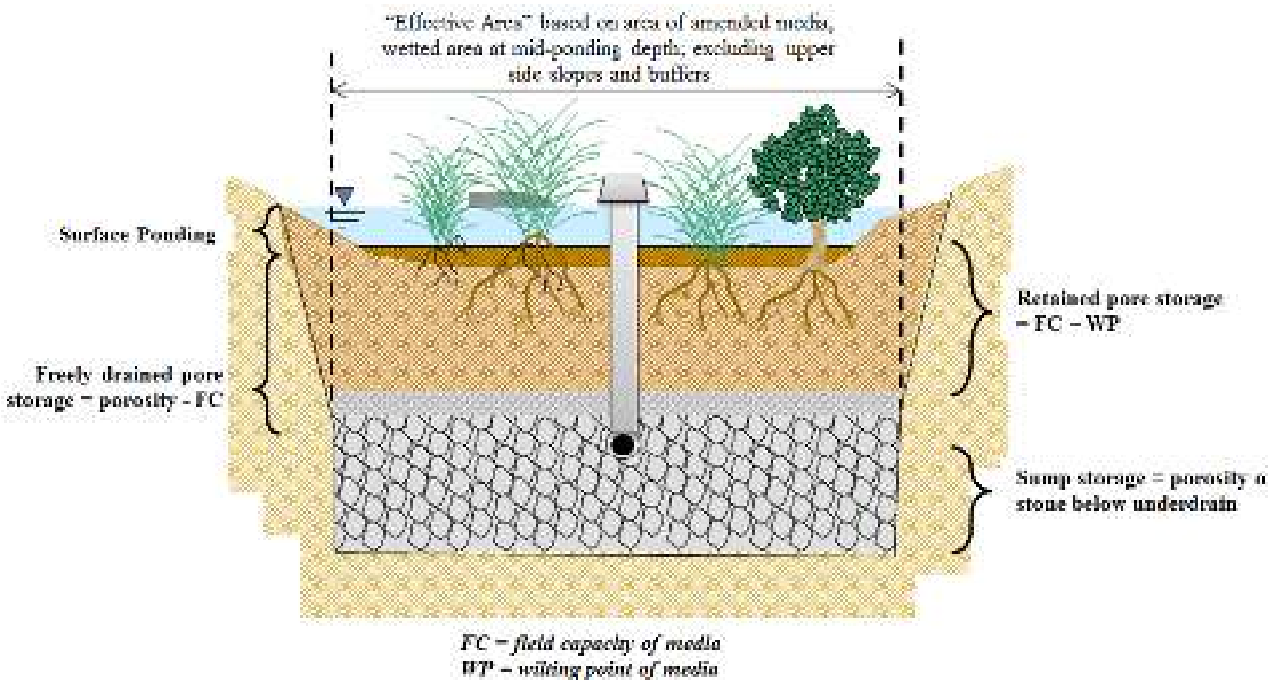


Figure B.5-1 Explanation of Biofiltration Volume Compartments for Sizing Purposes

Note: For sizing calculations, it shall be assumed that only 50% of the retained pore storage (field capacity – wilting point) is available for evapotranspiration to account for typical irrigation practices.

The numeric sizing criteria in this appendix are subdivided into:

- **Appendix B.5.1**: Standard[1] biofiltration BMP sizing; and
- **Appendix B.5.2:** Non-Standard[2] and Compact[3] biofiltration BMP sizing.

If a BMP meets the criteria in **Appendix B.5.1**, then it is considered compliant with the required pollutant control performance standard (i.e., for both retention and pollutant removal). It is not necessary to complete worksheets in this appendix for BMPs that meet the criteria in **Appendix B.5.1.** The volume retention performance standard for biofiltration BMPs is presented in **Figure B.5-2**.

When mapped hydrologic soil groups are used for feasibility screening, applicants are allowed to use the following reliable infiltration rates for sizing partial retention BMPs:

- Reliable infiltration rate for NRCS Type D soils = 0.05 in/hr.
- Reliable infiltration rate for NRCS Type C soils = 0.15 in/hr.

The applicant also has an option to perform infiltration testing in lieu of using the rates listed above.

If an applicant performs site-specific testing using a device that has a precision of 0.1 in/hr. and determines that the average measured infiltration rates in the DMA are less than 0.1 in/hr., then the applicant is allowed to size the biofiltration BMP assuming the DMA is a "No Infiltration Condition". In instances where the actual infiltration is not measured because the testing device has a precision of

0.1 in/hr., if the applicant elects to propose a non-standard or a compact biofiltration BMP then a reliable infiltration rate of 0.025 in/hr. must be used to size site design BMPs when there are no geotechnical and/or groundwater hazards identified in **Appendix C**.

If there are geotechnical and/or groundwater hazards identified in **Appendix C**, then the applicant must use a reliable infiltration rate of 0.0 in/hr. for estimating the target volume retention and sizing equivalent site design BMPs.

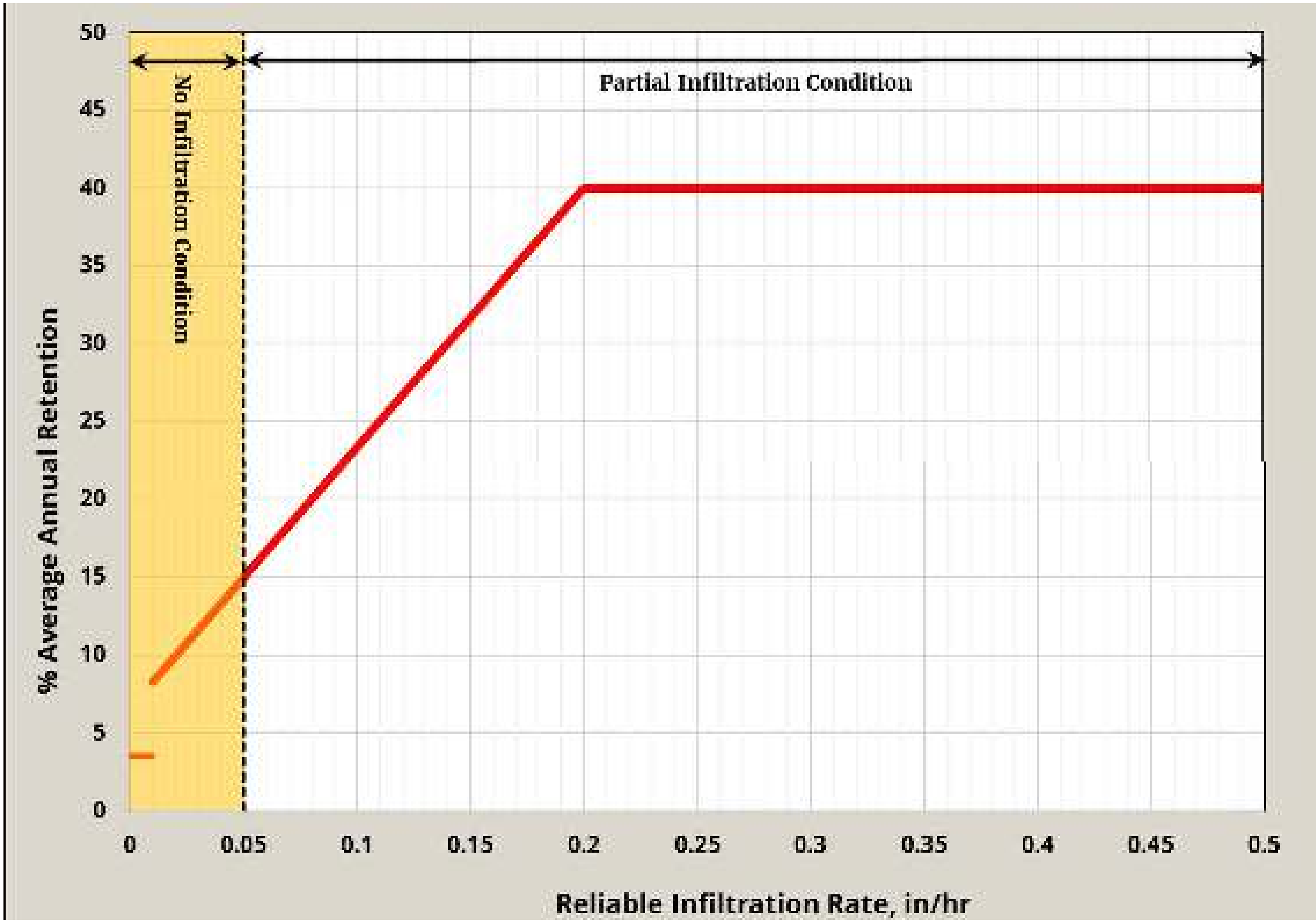
The required performance standards for different biofiltration BMPs are summarized in **Table B.5-1**.

---

[1] Standard biofiltration BMPs have a media filtration rate equal to or smaller than 5 in/hr. and a media surface area of 3% of contributing area times adjusted runoff factor or greater.

[2] Non-Standard biofiltration BMPs have a media filtration rate equal to or smaller than 5 in/hr. and a media surface area smaller than 3% of contributing area times adjusted runoff factor.

[3] Compact (high rate) biofiltration BMPs have a media filtration rate greater than 5 in/hr. and a media surface area smaller than 3% of contributing area times adjusted runoff factor. Compact biofiltration BMPs are typically proprietary BMPs that may qualify as biofiltration.



Note: For biofiltration BMP sizing, the reliable infiltration rate must be calculated using a factor of safety of 2 i.e., **Reliable infiltration rate = Measured infiltration rate/2**

Table B.5-1. Summary of Biofiltration Performance Standards

Infiltration Feasibility Condition	Performance Standard
Partial Infiltration Condition (Based on Worksheet C.4-1: Form I-8A and Worksheet C.4-2: Form I-8B) [There is no hierarchy in selecting the type of biofiltration BMP as long as the performance standard for the selected biofiltration BMP is met]	**Standard Biofiltration BMPs:** BMPs must meet the criteria in Appendix B.5.1.1
	Non-Standard Biofiltration BMPs: **Pollutant Removal:** BMP must be sized using Worksheet B.5-1 and Worksheet B.5-4; AND **Volume Retention:** DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented using Worksheet B.5-3 (to estimate retention from the BMP) and/or Worksheet B.5-7 (if dispersion and/or amended soils are proposed) and/or by implementing other site design BMPs (e.g. rain barrels, trees, etc.).
	Compact Biofiltration BMPs: **Pollutant Removal:** BMP must meet the criteria in Appendix F. Form I-10 must be completed and submitted with the PDP SWQMP; **AND** **Volume Retention:** DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented using Worksheet B.5-3 (to estimate retention from the BMP) and/or Worksheet B.5-7 (if dispersion and/or amended soils are proposed) and/or by implementing other site design BMPs (e.g. rain barrels, trees, etc.).
No Infiltration Condition (Based on Infiltration Feasibility Condition Letter and/or Worksheet C.4-1: Form I-8A and/or	**Standard Biofiltration BMPs:** BMPs must meet the criteria in Appendix B.5.1.2
	Non-Standard Biofiltration BMPs: **Pollutant Removal:** BMP must be sized using Worksheet B.5-1 and Worksheet B.5-4; **AND** **Volume Retention:** DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented by:

Infiltration Feasibility Condition	Performance Standard
Worksheet C.4-2: Form I-8B) [There is no hierarchy in selecting the type of biofiltration BMP as long as the performance standard for the selected biofiltration BMP is met]	• DMA has a combined BMP footprint and landscaped area (that meet the criteria in SD-B and SD-F factsheet) of 3% of contributing area times adjusted runoff factor or greater. The landscaped area must have an impervious area to pervious area ratio greater than 1.5:1. This can be documented using Worksheet B.5-6. [OR] • Applicant has an option to use other site design BMPs that will meet the target volume retention calculated using Worksheet B.5-2. This can be documented using Worksheet B.5-6 and/or Worksheet B.5-7.
	Compact Biofiltration BMPs: **Pollutant Removal:** BMP must meet the criteria in Appendix F. Form I-10 must be completed and submitted with the PDP SWQMP; **AND** **Volume Retention:** DMA must meet the target volume retention calculated using Worksheet B.5-2 (based on Figure B.5-2). Compliance with volume retention requirements can be documented by: • DMA has a combined BMP footprint and landscaped area (that meet the criteria in SD-B and SD-F factsheet) of 3% of contributing area times adjusted runoff factor or greater. The landscaped area must have an impervious area to pervious area ratio greater than 1.5:1. This can be documented using Worksheet B.5-6. [OR] • Applicant has an option to use other site design BMPs that will meet the target volume retention calculated using Worksheet B.5-2. This can be documented using Worksheet B.5-6 and/or Worksheet B.5-7.

B.5.1 Standard Biofiltration BMP Sizing

B.5.1.1 Standard Biofiltration Sizing for Partial Infiltration Condition

If a BMP meets the following criteria and the design criteria in PR-1 fact sheet (Appendix E.17), then the BMP is considered to meet its pollutant control performance standard.

1. DMA is categorized as "partial infiltration condition". Completed **Worksheet C.4-1: Form I 8A** and **Worksheet C.4-2: Form I-8B** are submitted with the PDP SWQMP;
2. BMP has a media surface area of 3% of contributing area times adjusted runoff factor or greater and does not have an impermeable liner on the bottom of the BMP;
3. Additional documentation (**Worksheet B.5-1**) that show the pollutant control requirements are met is included in the SWQMP submittal if the media filtration rate of the BMP is outlet controlled (example for outlet control: underdrain outlet retrofitted with an orifice cap that controls the filtration flow rate); **AND**
4. BMP provides an aggregate storage thickness greater than the thickness specified in
5. Table B.5-2 below the underdrain invert.

Table B.5-2. Reliable infiltration rate versus required aggregate storage

Reliable Infiltration Rate (in/hr)	Minimum Aggregate Storage Thickness (inches) below the underdrain invert
≥ 0.05 in/hr. and ≤ 0.10 in/hr.	6 inches
> 0.10 in/hr. and ≤ 0.15 in/hr.	12 inches
> 0.15 in/hr. and < 0.50 in/hr.	18 inches

Note: For biofiltration BMP sizing, the design infiltration rate must be calculated using a factor of safety of 2 i.e., **Reliable infiltration rate = Measured infiltration rate/2.**

When mapped hydrologic soil groups are used for feasibility screening, applicants are allowed to use the following reliable infiltration rates for sizing partial retention BMPs:

- o Reliable infiltration rate for NRCS Type D soils = 0.05 in/hr.
- o Reliable infiltration rate for NRCS Type C soils = 0.15 in/hr.

The applicant also has an option to perform infiltration testing in lieu of using the rates listed above.

To document compliance applicant must include the following information in the SWQMP submittal for each standard BMP:

- o Required BMP Footprint = Area draining to the BMP * Adjusted runoff factor * 0.03;
- o Provided BMP Footprint;
- o Reliable Infiltration rate;
- o Provided aggregate storage thickness below the underdrain invert;

- o Documentation that shows the BMP meets the requirements in PR-1 fact sheet (**Appendix E.17**); and
- o Completed **Worksheet B.5-1** if the BMP is the outlet controlled. **Worksheet B.5-1** is not required if the BMP is not outlet controlled.

B.5.1.2 Standard Biofiltration Sizing in No Infiltration Condition

If a BMP meets the following criteria and the design criteria in BF-1 fact sheet (Appendix E.18), then the BMP is considered to meet its pollutant control performance standard.

1. DMA is categorized as "no infiltration condition". Completed "Infiltration Feasibility Condition Letter" or Worksheet C.4-1: Form I-8A or Worksheet C.4-2: Form I-8B that supports the categorization submitted with the PDP SWQMP;
2. BMP has a media surface area of 3% of contributing area times adjusted runoff factor or greater and has an impermeable liner on the bottom of the BMP (applicant also has an option to not install an impermeable liner on the bottom of the BMP if there are no geotechnical/groundwater hazards identified while completing forms in **Appendix C**); **AND**
3. Additional documentation (**Worksheet B.5-1)** that show the pollutant control requirements are met is included in the SWQMP submittal if the media filtration rate of the BMP is outlet controlled (example for outlet control: underdrain outlet retrofitted with an orifice cap that controls the filtration flow rate).

To document compliance applicant must include the following information in the SWQMP submittal for each standard BMP:

- Required BMP Footprint = Area draining to the BMP * Adjusted runoff factor * 0.03;
- Provided BMP Footprint;
- Documentation that shows the BMP meets the requirements in BF-1 fact sheet (**Appendix E.18)**; and
- Completed **Worksheet B.5-1** if the BMP is the outlet controlled. **Worksheet B.5-1** is not required if the BMP is not outlet controlled.

BMPs that meet the criteria in **Appendix B.5.1** are not required to complete and submit Worksheets in **Appendix B.5.2** in the PDP SWQMP submittal (except in scenarios where the biofiltration BMP is outlet controlled in this case applicant must complete **Worksheet B.5-1** and include in the SWQMP submittal).

B.5.2 Non-Standard and Compact Biofiltration BMP Sizing

The following worksheets were developed for project applicants electing to use non-standard non-proprietary biofiltration BMPs and/or use compact biofiltration BMPs.

- **Worksheet B.5-1**: Sizing Method for Pollutant Removal Criteria
- **Worksheet B.5-2:** Sizing Method for Volume Retention Criteria
- **Worksheet B.5-3**: Volume Retention from Biofiltration with Partial Retention BMPs
- **Worksheet B.5-4**: Alternative Minimum Footprint Sizing Factor for Non-Standard Biofiltration
- **Worksheet B.5-5:** Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit
- **Worksheet B.5-6:** Volume Retention for No Infiltration Condition
- **Worksheet B.5-7**: Volume Retention from Amended Soils

Notes:

1. Project applicants that meet the criteria in **Appendix B.5.1** are not required to complete the worksheets in **Appendix B.5.2**.
2. Project applicants have an option to perform continuous simulation (following guidelines in Appendix G) to document conformance with the performance standard from Chapter 2 in lieu of using the worksheets in **Appendix B.5.2**.
   - If an applicant elects to perform continuous simulation, the applicant must model both the standard configuration (impervious footprint draining to a 3% biofiltration BMP) and the proposed configuration to show that proposed configuration would achieve volume reduction equal to or greater than the standard configuration. The modeling analysis must be documented in the PDP SWQMP.

Design Assumptions:

For the footprint of non-proprietary BMPs, applicants are allowed to use the plan view area at the surface of the BMP before any ponding, when performing sizing calculations using worksheets presented in **Appendix B.5.2**.

One of the following two methods may also be acceptable:

- **Method 1: Effective area/effective depth method**. This method involves determining the effective depth of water stored in the BMP and identifying the effective area at that elevation. For systems with vertical walls, the effective area is simply the plan view area. For systems with side slopes, the effective area can be approximated as the plan view area inundated when the ponded depth is half full. This is the area of the contour at an elevation half way between the surface of the BMP and the overflow elevation.

- **Method 2: Area takeoff/trapezoidal method**. For more complex BMP geometries, it may be necessary to perform area takeoffs at regular contour intervals within the BMP and apply trapezoidal geometry calculations. The effectively breaks the BMP into horizontal slices. Each horizontal "slice" would have a vertical thickness, an average surface area, and an effective porosity. The product of these values is the storage volume in the slice. The sum of all slices is the total storage volume. The effective area can then be estimated by dividing the total storage volume with depth.

In both methods, volume should only be tabulated below the overflow or bypass elevation of the BMP. Surcharge or freeboard storage should not be included in calculations. When one of the above two methods are used detailed calculations must be included in the SWQMP submittal.

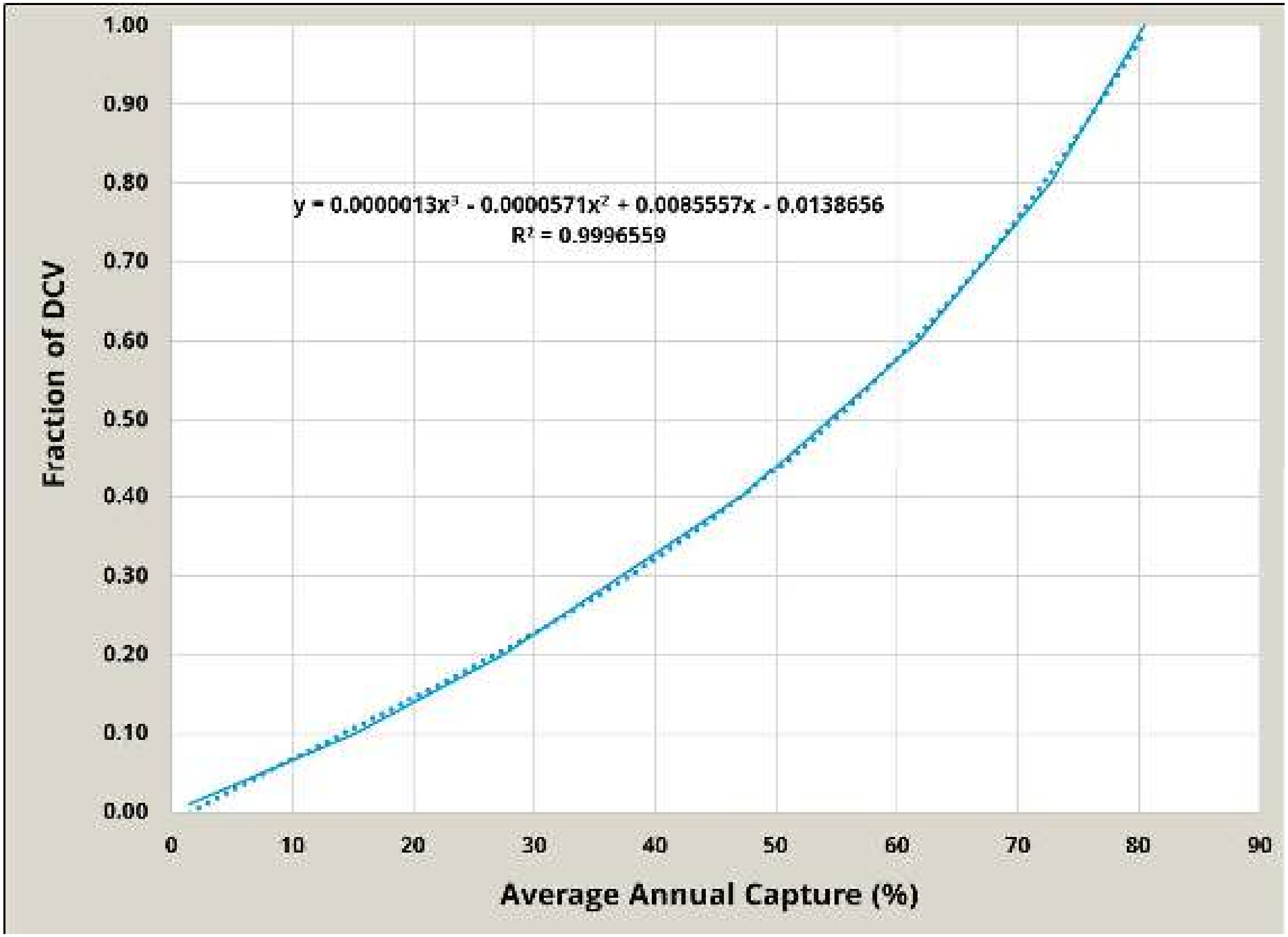
Area draining to the BMP must also include the area of the BMP. Use runoff factor for impervious are (i.e. concrete or asphalt) for the area of the BMP to determine the composite runoff factor for the DMA.

If an applicant performs site-specific testing using a device that has a precision of 0.1 in/hr. and determines that the measured infiltration rates in the DMA are less than 0.1 in/hr., then the applicant is allowed to size the biofiltration BMP assuming the DMA is a "No Infiltration Condition". In instances where the actual infiltration is not measured because the testing device has a precision of 0.1 in/hr., if the applicant elects to propose a non-Standard or a compact biofiltration BMP then a reliable infiltration rate of 0.025 in/hr. must be used to size site design BMPs when there are no geotechnical and/or groundwater hazards identified in **Appendix C**.

If there are geotechnical and/or groundwater hazards identified in **Appendix C**, then the applicant must use a reliable infiltration rate of 0.0 in/hr. for estimating the target volume retention and sizing equivalent site design BMPs.

The 36-hour drawdown percent capture nomograph that can be used to estimate the fraction of the DCV that must be retained to meet the average annual capture performance standard is presented in **Figure B.5-3** below.

Figure B.5-3. Fraction of DCV versus Average Annual Capture



Worksheet B.5-1: Sizing Method for Pollutant Removal Criteria

Sizing Method for Pollutant Removal Criteria		Worksheet B.5-1	
1	Area draining to the BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	85th percentile 24-hour rainfall depth		inches
4	Design capture volume [Line 1 x Line 2 x (Line 3/12)]		cu. ft.
BMP Parameter			
5	Surface ponding [6 inch minimum, 12 inch maximum]		inches
6	Media thickness [18 inches minimum], also add mulch layer and washed ASTM 33 fine aggregate sand thickness to this line for sizing calculations		inches
7	Aggregate storage (also add ASTM No 8 stone) above underdrain invert(12 inches typical) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
8	Aggregate storage below underdrain invert (3 inches minimum) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
9	Freely drained pore storage of the media	0.2	in/in
10	Porosity of aggregate storage	0.4	in/in
11	Media filtration rate to be used for sizing (maximum filtration rate of 5in/hr. with no outlet control; if the filtration rate is controlled by the outlet use the outlet-controlled rate (includes infiltration into the soil and flow rate through the outlet structure) which will be less than 5 in/hr.)		in/hr.
Baseline Calculations			
12	Allowable routing time for sizing	6	hours
13	Depth filtered during storm [Line 11 x Line 12]		inches
14	Depth of Detention Storage [Line 5 + (Line 6 x Line 9) + (Line 7 x Line 10) + (Line 8 x Line 10)]		inches
15	Total Depth Treated [Line 13 + Line 14]		inches
Option 1 – Biofilter 1.5 times the DCV			
16	Required biofiltered volume [1.5 x Line 4]		cu. ft.
17	Required Footprint [Line 16/ Line 15] x 12		sq. ft.
Option 2 - Store 0.75 of remaining DCV in pores and ponding			
18	Required Storage (surface + pores) Volume [0.75 x Line 4]		cu. ft.
19	Required Footprint [Line 18/ Line 14] x 12		sq. ft.
Footprint of the BMP			
20	BMP Footprint Sizing Factor (Default 0.03 or an alternative minimum footprint sizing factor from Line 11 in Worksheet B.5-4)		
21	Minimum BMP Footprint [Line 1 x Line 2 x Line 20]		sq. ft.
22	Footprint of the BMP = Maximum (Minimum (Line 17, Line 19), Line 21)		sq. ft.
23	Provided BMP Footprint		sq. ft.
24	Is Line 23 = Line 22? If Yes, then footprint criterion is met. If No, increase the footprint of the BMP.	☐ Yes	☐ No

Worksheet B.5-2: Sizing Method for Volume Retention Criteria

Sizing Method for Volume Retention Criteria		Worksheet B.5-2	
1	Area draining to the BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	85th percentile 24-hour rainfall depth		inches
4	Design capture volume [Line 1 x Line 2 x (Line 3/12)]		cu. ft.
Volume Retention Requirement			
5	Measured infiltration rate in the DMA Note: When mapped hydrologic soil groups are used enter 0.10 for NRCS Type D soils and for NRCS Type C soils enter 0.30 When in no infiltration condition and the actual measured infiltration rate is unknown enter 0.0 if there are geotechnical and/or groundwater hazards identified in Appendix C or enter 0.05		in/hr.
6	Factor of safety	2	
7	Reliable infiltration rate, for biofiltration BMP sizing [Line 5/ Line 6]		in/hr.
8	Average annual volume reduction target (Figure B.5-2) When Line 7 > 0.01 in/hr. = Minimum (40, 166.9 x Line 7 +6.62) When Line 7 ≤ 0.01 in/hr. = 3.5%		%
9	Fraction of DCV to be retained (Figure B.5-3) When Line 8 > 8% = 0.0000013 x Line 8^3 - 0.000057 x Line 8^2 + 0.0086 x Line 8 - 0.014 When Line 8 ≤ 8% = 0.023		
10	Target volume retention [Line 9 x Line 4]		cu. ft.

Worksheet B.5-3: Volume Retention from Biofiltration withPartial Retention BMPsVolume Retention from Biofiltration with Partial Retention BMPs		Worksheet B.5-3	
1	Area draining to the BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	85th percentile 24-hour rainfall depth		inches
4	Design capture volume [Line 1 x Line 2 x (Line 3/12)]		cu. ft.
BMP Parameters			
5	Footprint of the BMP		sq. ft.
6	Media thickness [18 inches minimum], also add mulch layer and washed ASTM 33 fine aggregate sand thickness to this line for sizing calculations		inches
7	Media retained pore space [50% of (Field Capacity-Wilting Point)]	0.05	in/in
8	Aggregate storage below underdrain invert (3 inches minimum) – use 0 inches if the aggregate is not over the entire bottom surface area		inches
9	Porosity of aggregate storage	0.4	in/in
10	Measured infiltration rate in the DMA Note: When mapped hydrologic soil groups are used enter 0.10 for NRCS Type D soils and for NRCS Type C soils enter 0.30		in/hr.
11	Factor of safety	2	
12	Reliable infiltration rate, for biofiltration BMP sizing [Line 10/ Line 11]		in/hr.
Evapotranspiration: Average Annual Volume Retention			
13	Effective evapotranspiration depth [Line 6 x Line 7]		inches
14	Retained pore volume [(Line 13 x Line 5)/12]		cu. ft.
15	Fraction of DCV retained in pore spaces [Line 14/Line 4]		
16	Evapotranspiration average annual capture [use ET Nomographs in Figure B.5-5, Refer to Appendix B.5.4]		%
Infiltration: Average Annual Volume Retention			
17	Drawdown for infiltration storage [(Line 8 x Line 9)/Line 12]		hours
18	Equivalent DCV fraction from evapotranspiration (use Line 16 and Line 17 in Figure B.4-1; Refer to Appendix B.4.2.2)		
19	Infiltration volume storage [(Line 5 x Line 8 x Line 9)/12]		cu. ft.
20	Infiltration storage: Fraction of DCV [Line 19 /Line 4]		
21	Total Equivalent Fraction of DCV [Line 18 + Line 20]		
22	Biofiltration BMP average annual capture [use Line 21 and 17 in Figure B.4-1]		%
23	Fraction of DCV retained (Figure B.5-3) $0.0000013 \times \text{Line } 22^3 - 0.000057 \times \text{Line } 22^2 + 0.0086 \times \text{Line } 22 - 0.014$		
24	Volume retention achieved by biofiltration BMP [Line 23 x Line 4]		cu. ft.

B.5.2.1 Alternative Minimum Sizing factor for Clogging Risk

Worksheet B.5-4 below must be used to support a request for an alternative minimum footprint sizing factor (for clogging) in **Worksheet B.5-1**. Based on a review of the submitted worksheet and supporting documentation, the use of a smaller footprint sizing factor may be approved at the discretion of the City Engineer. If approved, the estimated footprint from the worksheet below can be used in line 20 of **Worksheet B.5-1** in lieu of the 3 percent minimum footprint value.

This worksheet includes the following general steps to calculate the minimum footprint sizing factor:

- Select a "load to clog" that is representative of the type of BMP proposed
- Select a target life span (i.e., frequency of major maintenance) that is acceptable to the City
- Engineer. A default value of 10 years is recommended.
- Compile information about the DMA from other parts of the SWQMP development process.
- Determine the event mean concentration (EMC) of TSS that is appropriate for the DMA
- Perform calculations to determine the minimum footprint to provide the target lifespan.

Table B.5-3: Typical land use total suspended solids (TSS) event mean concentration (EMC) values.

Land Use	TSS EMC[4], mg/L
Single Family Residential	123
Commercial	128
Industrial	125
Education (Municipal)	132
Transportation[5]	78
Multi-family Residential	40
Roof Runoff[6]	14
Low Traffic Areas[7]	50
Open Space	216

[4] EMCs are from SBPAT datasets for SLR and SDR Watersheds – Arithmetic Estimates of the Lognormal Summary Statistics for San Diego, unless otherwise noted.
[5] EMCs are based on Los Angeles region default SBPAT datasets due to lack of available San Diego data.
[6] Value represents the average first flush concentration for roof runoff (Charters et al., 2015).
[7] Davis and McCuen (2005)

TableB.5-4: Guidance for Selecting Load to Clog (LC)

BMP Configuration	Load to Clog, L_c, lb/sq-ft
Baseline: Approximately 50 percent vegetative cover; typical fine sand and compost blend	2
Baseline + increase vegetative cover to at least 75 percent	3
Baseline + include coarser sand to increase initial permeability to 20 to 30 in/hr; control flowrate with outlet control	3
Baseline + increase vegetative cover and include more permeable media with outlet control, per above	4

References

Charters, F.J., Cochrane, T.A., and O'Sullivan, A.D., (2015). Particle Size Distribution Variance in Untreated Urban Runoff and its implication on treatment selection. Water Research, 85 (2015), pg. 337-345.

Davis, A.P. and McCuen, R.H., (2005). Stormwater Management for Smart Growth. Springer Science & Business Media, pg. 155.

Maniquiz-Redillas, M.C., Geronimo, F.K.F, and Kim, L-H. Investigation on the Effectiveness of Pretreatment in Stormwater Management Technologies. Journal of Environmental Sciences, 26 (2014), pg. 1824-1830.

Pitt, R. and Clark, S.E., (2010). Evaluation of Biofiltration Media for Engineered Natural Treatment Systems. Geosyntec Consultants and The Boeing Company.

Worksheet B.5-4: Calculation of Alternative Minimum Footprint Sizing Factor for Non-Standard Biofiltration

Alternative Minimum Footprint Sizing Factor for Non-Standard Biofiltration			Worksheet B.5-4	
1	Area draining to the BMP			sq. ft.
2	Adjusted Runoff Factor for drainage area (Refer to Appendix B.1 and B.2)			
3	Load to Clog (default value when using Appendix E fact sheets is 2.0)			lb/sq. ft.
4	Allowable Period to Accumulate Clogging Load (T_L) (default value is 10)			years
Volume Weighted EMC Calculation				
Land Use		**Fraction of Total DCV**	**TSS EMC (mg/L)**	**Product**
Single Family Residential			123	
Commercial			128	
Industrial			125	
Education (Municipal)			132	
Transportation			78	
Multi-family Residential			40	
Roof Runoff			14	
Low Traffic Areas			50	
Open Space			216	
Other, specify:				
Other, specify:				
Other, specify:				
5	Volume Weighted EMC (sum of all products)			mg/L
Sizing Factor for Clogging				
6	Adjustment for pretreatment measures Where: Line 6 = 0 if no pretreatment; Line 6 = 0.25 when pretreatment is included; Line 6 = 0.5 if the pretreatment has an active Washington State TAPE approval rating for "pre-treatment."			
7	Average Annual Precipitation [Provide documentation of the data source in the discussion box; SanGIS has a GIS layer for average annual precipitation]			inches
8	Calculate the Average Annual Runoff (Line 7/12) x Line 1 x Line2			cu-ft/yr
9	Calculate the Average Annual TSS Load (Line 8 x 62.4 x Line 5 x (1 – Line 6))/10^6			lb/yr
10	Calculate the BMP Footprint Needed (Line 9 x Line 4)/Line 3			sq. ft.
11	Calculate the Minimum Footprint Sizing Factor for Clogging [Line 10/ (Line 1 x Line 2)]			
Discussion:				

B.5.2.2 Sizing Biofiltration BMPs Downstream of a Storage Unit

Introduction

In scenarios, where the BMP footprint is governed based on Option 1 (Line 17 of Worksheet B.5-1) or the required volume reduction for partial infiltration conditions (Line 10 of Worksheet B.5-2) the footprint of the biofiltration BMP can be reduced using the sizing calculations in this **Appendix B.5.2.2** when there is an upstream storage unit (e.g. cistern) that can be used to regulate the flows through the biofiltration BMP.

When this approach is used for sizing biofiltration BMPs the applicant must also verify that the storage unit meets the hydromodification management drawdown requirements and the discharge from the downstream biofiltration BMP will still meet the hydromodication flow control requirements. These calculations must be documented in the PDP SWQMP.

This methodology is **not** applicable when the minimum footprint factor is governed based on the alternative minimum footprint sizing factor calculated using Worksheet B.5-4 (Line 11). A biofiltration BMP smaller than the alternative minimum footprint sizing factor is considered compact biofiltration BMP and may be allowed at the discretion of the City Engineer if the BMP meets the requirements in **Appendix F** and the applicant submits a completed Form I-10.

Sizing Calculation

Sizing calculations for the biofiltration footprint must demonstrate that one of the following two equivalent performance standards is met:

1. Use continuous simulation and demonstrate the following is met:
   (a) The BMP or series of BMPs biofilters at least 92 percent of average annual (long term) runoff volume and achieves a volume reduction equivalent to Line 10 of **Worksheet B.5-2**. This can be demonstrated through reporting of output from the San Diego Hydrology Model, or through other continuous simulation modeling meeting the criteria in **Appendix G**, as acceptable to the City Engineer. The 92 percent of average annual runoff treatment corresponds to the average capture achieved by implementing a BMP with 1.5 times the DCV and a drawdown time of 36 hours (**Appendix B.4.2**).
2. Use the simple optimized method in **Worksheet B.5-5**. The applicant is also required to complete Worksheet B.5-1, B.5-2 and B.5-4 when the applicant elects to use Worksheet B.5-5 to reduce the biofiltration BMP footprint. **Worksheet B.5-5** was developed to satisfy the following two criteria as applicable:
   (a) Greater than 92 percent of the average annual runoff volume from the storage unit is routed to the biofiltration BMP through the low flow orifice and the peak flow from the low flow orifice can instantaneously be filtered through the biofiltration media. If the outlet design for the storage unit includes orifices at different elevations and an overflow structure, only flows from the overflow structure should be excluded from the calculation (both for 92 percent capture and for peak flow to the biofiltration BMP that needs to be instantaneously filtered), unless the flows from other orifices also bypass the biofiltration BMP, in which case flows from the orifices that bypass should also be excluded.

(b) The retention losses from the optimized biofiltration BMP are equal to or greater than the retention losses from the conventional biofiltration BMP. This second criterion is only applicable for partial infiltration condition.

For drawdown times that are outside the range of values presented in Table B.5-5 below, the storage unit should be designed to discharge greater than 92% average annual capture to the downstream Biofiltration BMP.

Table B.5-5: Storage required for different drawdown times

Drawdown Time (hours)	Storage requirement (below the overflow elevation, or below outlet elevation that bypass the biofiltration BMP)
12	0.85 DCV
24	1.25 DCV
36	1.50 DCV
48	1.80 DCV
72	2.20 DCV
96	2.60 DCV
120	2.80 DCV

Worksheet B.5-5: Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit

Optimized Biofiltration BMP Footprint when Downstream of a Storage Unit		Worksheet B.5-5	
1	Area draining to the storage unit and biofiltration BMP		sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)		
3	Effective impervious area draining to the storage unit and biofiltration BMP [Line 1 x Line 2]		sq. ft.
4	Remaining DCV after implementing retention BMPs		cu. ft.
5	Design infiltration rate (measured infiltration rate / 2)		ft./hr.
6	Media Thickness [1.5 feet minimum], also add mulch layer and washed ASTM 33 fine aggregate sand thickness to this line for sizing calculations		ft.
7	Media filtration rate to be used for sizing (0.42 ft/hr. with no outlet control; if the filtration rate is controlled by the outlet use the outlet controlled rate)		ft./hr.
8	Media retained pore space	0.05	in./in.
Storage Unit Requirement			
9	Drawdown time of the storage unit, minimum (from the elevation that bypasses the biofiltration BMP, overflow elevation)		hours
10	Storage required to achieve greater than 92 percent capture (see Table B.5-5)		fraction
11	Storage required in cubic feet (Line 4 x Line 10)		cu. ft.
12	Storage provided in the design, minimum (from the elevation that bypasses the biofiltration BMP, overflow elevation)		cu. ft.
13	Is Line 12 ≥ Line 11. If no increase storage provided until this criteria is met	☐ Yes	☐ No
Criteria 1: BMP Footprint Biofiltration Capacity			
14	Peak flow from the storage unit to the biofiltration BMP (using the elevation used to evaluate the percent capture)		cfs
15	Required biofiltration footprint [(3,600 x Line 14)/Line 7]		sq. ft.
Criteria 2: Alternative Minimum Sizing Factor (Clogging)			
16	Alternative Minimum Footprint Sizing Factor [Line 11 of Worksheet B.5-4]		Fraction
17	Required biofiltration footprint [Line 3 x Line 16]		sq. ft.
Criteria 3: Retention requirement [Not applicable for No Infiltration Condition]			
18	Retention Target (Line 10 in Worksheet B.5-2)		cu. ft.
19	Average discharge rate from the storage unit to the biofiltration BMP		cfs
20	Depth retained in the optimized biofiltration BMP {Line 6 x Line 8} + {[(Line 4)/(2400 x Line 19)] x Line 5}		ft.
21	Required optimized biofiltration footprint (Line 18/Line 20)		sq. ft.
Optimized Biofiltration Footprint			
22	Optimized biofiltration footprint, maximum (Line 15, Line 17, Line 21)		sq. ft.

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Worksheet B.5-6: Volume Retention for No Infiltration Condition

Volume Retention for No Infiltration Condition						Worksheet B.5-6
1	Area draining to the biofiltration BMP					sq. ft.
2	Adjusted runoff factor for drainage area (Refer to Appendix B.1 and B.2)					
3	Effective impervious area draining to the BMP [Line 1 x Line 2]					sq. ft.
4	Required area for Evapotranspiration [Line 3 x 0.03]					sq. ft.
5	Biofiltration BMP Footprint					sq. ft.
Landscape Area (must be identified on DS-3247)						
	Identification	**A**	**B**	**C**	**D**	**E**
6	Landscape area that meet the requirements in SD-B and SD-F Fact Sheet (sq. ft.)					
7	Impervious area draining to the landscape area (sq. ft.)					
8	Impervious to Pervious Area ratio [Line 7/Line 6]					
9	Effective Credit Area If Line 8 >1.5, use Line 6; if not use Line 7/1.5					
10	Sum of Landscape area [sum of Lines 9A-9E]					sq. ft.
11	Provided footprint for evapotranspiration [Line 5 + Line 10]					sq. ft.
Volume Retention Performance Standard						
12	Is Line 11 ≥ Line 4? If yes, then volume retention performance standard for no infiltration condition is met. If no, proceed to Line 13				☐ Yes	☐ No
13	Fraction of the performance standard met through the BMP footprint and/or landscaping [Line 11/Line 4]					
14	Target Volume Retention [Line 10 from Worksheet B.5.2]					cu. ft.
15	Volume retention required from other site design BMPs [(1-Line 13) x Line 14]					cu. ft.
Site Design BMP						
	Identification	**Site Design Type**			**Credit**	
16	**A**					cu. ft.
	B					cu. ft.
	C					cu. ft.
	D					cu. ft.
	E					cu. ft.
	Sum of volume retention benefits from other site design BMPs (e.g. trees; rain barrels etc.). [sum of Lines 16A-16E] Provide documentation of how the site design credit is calculated in the PDP SWQMP.					cu. ft.
17	Is Line 16 ≥ Line 15? If yes, then volume retention performance standard for no infiltration condition is met. If no, implement additional site design BMPs.				☐ Yes	☐ No

Worksheet B.5-7: Volume Retention from Amended Soils

Volume Retention From Amended Soils		Worksheet B.5-7	
1	Impervious area draining to the pervious area		sq. ft.
2	Pervious area (must meet the requirements in SD-B and SD-F Fact Sheets)		sq. ft.
3	Dispersion Ratio [Line 1/Line 2] Note: This worksheet is not applicable when Line 3 > 50 or Line 3 < 0.25		
4	Adjusted runoff factor [(Line 1 * 0.9 + Line 2 * 0.1) / (Line 1 + Line 2)]		
5	85th percentile 24-hour rainfall depth		inches
6	Design capture volume [(Line 1 + Line 2) x Line 4 x (Line 5/12)]		cu. ft.
7	Amendment Depth (Choose from 3", 6", 9", 12", 15" and 18")		inches
8	Storage [(porosity – field capacity) + 0.5 * (field capacity – wilting point)]	0.25	in./in.
9	Pervious Storage [Line 2 * (Line 7/12) * Line 8]		cu. ft.
10	Fraction of DCV [Line 9 / Line 6]		
11	Measured Infiltration Rate When mapped hydrologic soil groups are used enter 0.10 for NRCS Type D soils and for NRCS Type C soils enter 0.30 When in no infiltration condition and the actual measured infiltration rate is unknown enter 0.0 if there are geotechnical and/or groundwater hazards identified in Appendix C or enter 0.05		in/hr.
12	Factor of Safety	2	
13	Reliable Infiltration Rate [Line 11/Line 12]		in/hr.
14	Dispersion Credit (Based on Figures B.5.6 to B.5.11; Line 10 and Line 13)		
15	Volume retention due to amendment [Line 1 * (Line 5/12) * Line 14]		cu. ft.

The following criteria must be met to get volume reduction credit from amended soils:

- Pervious area must not have an underdrain;
- If pervious area has an impermeable liner, the applicant must use 0.000001 in/hr. for reliable infiltration rate;
- Impervious area must be dispersed uniformly across the pervious area and at non-erosive velocities;
- Pervious area must have a minimum width of 10 feet (exemption to this minimum width criterion is allowed when the contributing flow path length of the impervious area /pervious area width ≤ 2) and a maximum slope of 5%; **and**
- Impervious to pervious area ratio must be less than 50:1.

The applicants have an option to deviate from the criteria listed above, in this case the applicant must perform site specific continuous simulation modeling (following guidelines in Appendix G) to estimate the volume retention benefits from the amended soils and document the analysis in the PDP SWQMP.

B.5.3 Basis for Minimum Sizing Factor for Biofiltration BMPs

B.5.3.1 Introduction

MS4 Permit Provision E.3.c.(1)(a)(i)

The MS4 Permit describes conceptual performance goals for biofiltration BMPs and specifies numeric criteria for sizing biofiltration BMPs (See Section 2.2.1 of this Manual). However, the MS4 Permit does not define a specific footprint sizing factor or design profile that must be provided for the BMP to be considered "biofiltration." Rather, the MS4 Permit specifies (Footnote 29):

> **As part of the Copermittee's update to its BMP Design Manual, pursuant to Provision E.3.d, the Copermittee must provide guidance for hydraulic loading rates and other biofiltration design criteria necessary to maximize storm water retention and pollutant removal.**

To meet this provision, this manual includes specific criteria for design of biofiltration BMPs. Among other criteria, a minimum footprint sizing factor of 3 percent (BMP footprint area as percent of contributing area times adjusted runoff factor) and a volume retention performance standard (FigureB.5-2) based on the reliable infiltration rate at the site (i.e. measured infiltration rate/2) is specified. The purpose of this section is to provide the technical rationale for this 3 percent minimum sizing factor and the volume retention performance standard.

B.5.3.2 Conceptual Need for Minimum Sizing Factor

Under the 2011 Model SUSMP, a sizing factor of 4 percent was used for sizing biofiltration BMPs. This value was derived based on the goal of treating the runoff from a 0.2 inch per hour uniform precipitation intensity at a constant media flow rate of 5 inches per hour. While this method was simple, it was considered to be conservative as it did not account for significant transient storage present in biofiltration BMPs (i.e., volume in surface storage and subsurface storage that would need to fill before overflow occurred). Under this manual, biofiltration BMPs will typically provide subsurface storage to promote infiltration losses; therefore, typical BMP profiles will tend to be somewhat deeper than those provided under the 2011 Model SUSMP. A deeper profile will tend to provide more transient storage and allow smaller footprint sizing factors while still providing similar or better treatment capacity and pollutant removal. Therefore, a reduction in the minimum sizing factor from the factor used in the 2011 Model SUSMP is supportable. However, as footprint decreases, issues related to potential performance, operations, and/or maintenance can increase for a number of reasons:

1. As the surface area of the media bed decreases, the sediment loading per unit area increases, increasing the risk of clogging. While vigorous plant growth can help maintain permeability of soil, there is a conceptual limit above which plants may not be able to mitigate for the sediment loading. Scientific knowledge is not conclusive in this area.
2. With smaller surface areas and greater potential for clogging, water may be more likely to bypass the system via overflow before filling up the profile of the BMP.
3. As the footprint of the system decreases, the amount of water that can be infiltrated from subsurface storage layers and evapotranspire from plants and soils tends to decrease.

4. With smaller sizing factors, the hydraulic loading per unit area increases, potentially reducing the average contact time of water in the soil media and diminishing treatment performance.

The MS4 Permit requires that volume and pollutant retention be maximized. Therefore, a minimum sizing factor was determined to be needed. This minimum sizing factor does not replace the need to conduct sizing calculations as described in this manual; rather it establishes a lower limit on required size of biofiltration BMPs as the last step in these calculations. Additionally, it does not apply to alternative biofiltration designs that utilize the checklist in **Appendix F** (Biofiltration Standard and Checklist). Acceptable alternative designs (such as proprietary systems meeting **Appendix F** criteria) typically include design features intended to allow acceptable performance with a smaller footprint and have undergone field scale testing to evaluate performance and required O&M frequency.

B.5.3.3 Lines of Evidence to Select Minimum Sizing Factor

Three primary lines of evidence were used to select the minimum sizing factor of 3 percent (BMP footprint area as percent of contributing area times adjusted runoff factor) in this manual:

1. Typical design calculations.
2. Volume reduction performance.
3. Sediment clogging calculations.

These lines of evidence and associated findings are explained below.

Typical Design Calculations

A range of BMP profiles were evaluated for different design rainfall depths and soil conditions. **Worksheet B.5-1** was used for each case to compute the required footprint sizing factor. For these calculations, the amount of water filtered during the storm event was determined based on a media filtration rate of 5 inches per hour and a routing time of 6 hours. These input assumptions are considered to be well-supported and consistent with the intent of the MS4 Permit. These calculations generally yielded footprint sizing factors between 1.5 and 4.9 percent. In the interest of establishing a uniform County-wide minimum sizing factor, a 3 percent sizing factor was selected from this range, consistent with other lines of evidence.

Volume Reduction Performance

Consistent with guidance in Fact Sheet PR-1, the amount of retention storage (in gravel sump below underdrain) that would drain in 36 hours was calculated for a range of soil types. This was used to estimate the volume reduction that would be expected to be achieved. For a sizing factor of 3 percent and a soil filtration rate of 0.20 inches per hour (NRCS Type B Soils, moderate infiltration rates), the average annual volume reduction was estimated to be approximately 40 percent (via percent capture method; see **Appendix B.4.2**).

In describing the basis for equivalency between retention and biofiltration (1.5 multiplier), the MS4 Permit Fact Sheet referred to analysis prepared in the Ventura County Technical Guidance Manual. The Ventura County analysis considered the pollutant treatment as well as the volume reduction provided by biofiltration in considering equivalency to retention. This analysis assumed an average long-term volume reduction of 40 percent based on analysis of data from the International Stormwater BMP Database. The calculations of estimated volume reduction at a 3 percent sizing factor is (previous paragraph) consistent with this value. While estimated volume reduction is sensitive to site-specific factors, this analysis suggests that a sizing factor of approximately 3 percent provides levels of volume reduction that are reasonably consistent with the intent of the MS4 Permit.

Volume Retention Performance Standard

The volume retention performance standard in Figure B.5-2 was developed to allow for adjustment of the volume retention requirement based on the type of soils present onsite. Constrained sites with poorly draining soils may not be able to install BMPs having a sufficient footprint to satisfy 40% retention performance standard. As such, a sliding scale was developed to adjust the performance standard to match the ability of the site to infiltrate. In effect, the sliding scale produces similar BMP footprint sizes across a varying range of infiltration rates (up to 0.20 inches per hour) for a given 85th percentile 24-hour storm depth.

The "sliding scale" portion (i.e. the sloped portion of the line) of the performance standard indicated in **Figure B.5-2** was determined by estimating the retention associated with a very low infiltration rate (effectively the Y-axis intercept) and then connecting that point to the unadjusted performance standard (0.2 in/hr. infiltration rate, 40% average annual retention) with a straight line. The unadjusted performance standard is based on a 3% BMP footprint size factor and results in a rainfall depth of approximately 0.74 inches. Fixing this rainfall depth and using the same 3% BMP footprint factor, the feasible retention associated with an infiltration rate of 0.01 inches per hour (very low) was estimated using the drawdown percent capture curves presented in **Figure B.4-1** and ET percent capture curves presented in **Figure B.5-5**. The resulting retention was estimated to be 8.3% (for 0.01 in/hr. infiltration rate), which became the starting poin

t of the line that then connects to the unadjusted performance standard (0.2 in/hr., 40% retention). The resulting performance standard curve allows flexibility in the design of BMPs or site design features while ensuring consistent performance within the City.

Sediment Clogging Calculations

As sediment accumulates in a filter, the permeability of the filter tends to decline. The lifespan of the filter bed can be estimated by determining the rate of sediment loading per unit area of the filter bed. To determine the media bed surface area sizing factor needed to provide a target lifespan, simple sediment loading calculations were conducted based on typical urban conditions. The inputs and results of this calculation are summarized in **Table B.5-6**.

Table B.5-6: Inputs and Results of Clogging Calculation

Parameter	Value	Source
Representative TSS Event Mean Concentration, mg/L	100	Approximate average of San Diego Land Use Event Mean Concentrations from San Diego River and San Luis Rey River WQIP
Runoff Coefficient of Impervious Surface	0.90	Table B.1-1
Runoff Coefficient of Pervious Surface	0.10	Table B.1-1 for landscape areas
Imperviousness	40% to 90%	Planning level assumption, covers typical range of single family to commercial land uses
Average Annual Precipitation, inches	11 to 13	Typical range for much of urbanized San Diego County
Load to Initial Maintenance, kg/m²	10	Pitt, R. and S. Clark, 2010. Evaluation of Biofiltration Media for Engineered Natural Treatment Systems.
Allowable period to initial clogging, yr	10	Planning-level assumption
Estimated BMP Footprint Needed for 10-Year Design Life	2.8% to 3.3%	Calculated

This analysis suggests that a 3 percent sizing factor, coupled with sediment source controls and careful system design, should provide reasonable protection against premature clogging. However, there is substantial uncertainty in sediment loading and the actual load to clog that will be observed under field conditions in the San Diego climate. Additionally, this analysis did not account for the effect of plants on maintaining soil permeability. Therefore, this line of evidence should be considered provisional, subject to refinement based on field scale experience. As field scale experience is gained about the lifespan of biofiltration BMPs in San Diego and the mitigating effects of plants on long term clogging, it may be possible to justify lower factors of safety and therefore smaller design sizes in some cases. If a longer lifespan is desired and/or greater sediment load is expected, then a larger sizing factor may be justified.

B.5.3.4 Discussion

Generally, the purpose of a minimum sizing factor is to help improve the performance and reliability of standard biofiltration systems and limit the use of sizing methods and assumptions that may lead to designs that are less consistent with the intent of the MS4 Permit.

Ultimately, this factor is a surrogate for a variety of design considerations, including clogging and associated hydraulic capacity, volume reduction potential, and treatment contact time. A prudent design approach should consider each of these factors on a project-specific basis and identify whether site conditions warrant a larger or smaller factor. For example, a system treating only rooftop runoff in an area without any allowable infiltration may have negligible clogging risk and negligible volume reduction potential – a smaller sizing factor may not substantially reduce performance in either of these areas. Alternatively, for a site with high sediment load and limited pre-treatment potential, a larger sizing factor may be warranted to help mitigate potential clogging risks. The City Engineer has discretion to accept alternative sizing factor(s) based on project-specific considerations. Additionally, the recommended minimum sizing factor may change over time as more experience with biofiltration is obtained.

B.5.4 Volume Retention Mechanisms

A series of nomographs were developed using United States Environmental Protection Agency (USEPA) SWMM and parameters listed in **Appendix G** for the Lake Wohlford rain gage and presented in this **Appendix B.5.4** to provide applicants tools to quantify volume retention achieved by a BMP and/or a site design feature that is implemented at the project site.

B.5.4.1 Technical Framework

The total amount of volume retention (reduction) achieved through a BMP and/or site design feature is a function of the amount of water that enters the BMP and/or a site design feature and does not immediately overflow (i.e., the amount of water that is captured), and the portion of the captured water that is "lost" via infiltration, evapotranspiration, and/or consumptive use (i.e., the total of all three is the volume reduction), such that it does not discharge directly to surface water.

When evaluating volume retention and capture efficiency, each BMP and/or site design can be considered to consist of a set of storage compartments, each with a distinct storage volume, discharge rate, and pathway by which water discharges (i.e., surface discharge, infiltration, evapotranspiration). Figure B.5-4 illustrates this concept. When storage capacity is available in a given compartment, then that compartment of the BMP and/or site design can capture additional inflow.

When storage capacity is not available in a given compartment to accept additional inflow, then inflowing water either fills the next storage compartment of the BMP and/or site design or bypasses the system (if no additional storage is available). The volume retention and capture performance of a BMP and/or site design is primarily a function of the amount of storage volume provided and the rate at which the storage drains to volume retention pathways (i.e., infiltration, evapotranspiration, consumptive use) versus surface discharge pathways.

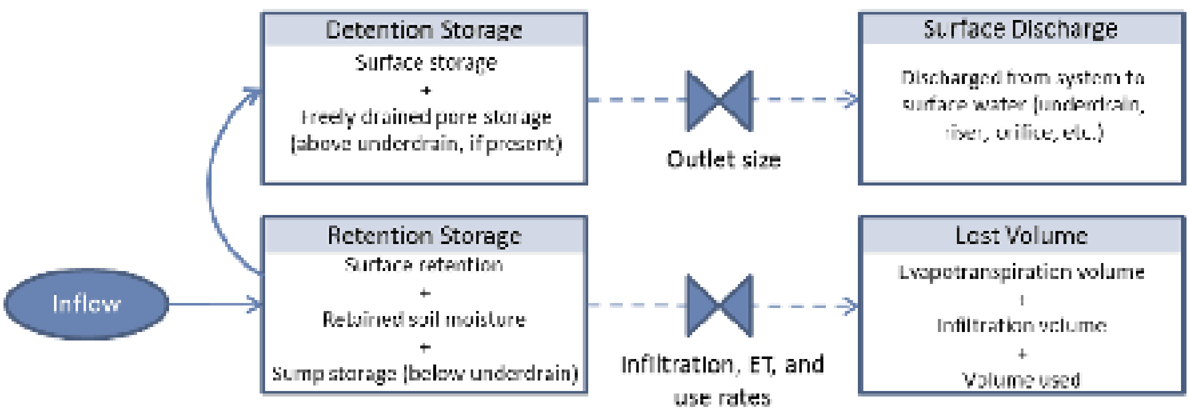

Figure B.5-4. Schematic Representation for Purpose of Volume Retention Analysis

Capture efficiency (or "percent capture") is a metric that measures the percent of rainfall that is captured and managed by a BMP and/or a site design feature (i.e., does not bypass or immediately overflow). Captured storm water may be infiltrated, evapotranspired, or retained for harvest and use, and/or treated and released. Capture efficiency is typically expressed as annual average percent capture. Runoff volume that is not captured by a BMP and/or site design feature is referred to as bypass or overflow. Volume reduction processes can only occur in a BMP and/or site design feature when water is captured.

Long term capture efficiency is primarily a function of the BMP and/or site design feature storage volume (relative to the size and the DCV of the DMA), the drawdown rate and pattern of the storage compartment, and rainfall pattern. Practically, this means that the following parameters can be isolated as primary predictors of capture efficiency for the purpose of developing an approximate predictive tool:

- **Normalized storage volume**, expressed as a fraction of DCV. For example, a 1,000 cubic foot storage volume for a watershed that is 1 acre with a runoff coefficient of 0.9 and an 85th percentile rainfall depth of 0.6 inches would translate to 0.51 times the DCV [1,000 cu-ft × 12in/ft. / (1 ac × 43,560 sq-ft/ac × 0.9 x 0.6 in)].
- **Drawdown time of the storage volume**. For BMP and/or site design feature storage elements with nominally consistent drawdown rates regardless of season (i.e., infiltration, filtration, orifice-controlled surface discharge), the representative drawdown time can be expressed in hours. For example, a bioretention area with an effective storage depth of 12 inches and an underlying design infiltration rate of 0.2 inches per hour would have a nominal drawdown time of 60 hours (12 inches / 0.2 in/hr.). For BMP and/or site design feature storage elements with seasonally varying drawdown rates (i.e., storage drained by evapotranspiration or irrigation-based consumptive use), the concept of a representative drawdown time is not applicable. In this case, the evapotranspiration storage depth (i.e., the amount of potential evapotranspiration that must occur for the stored water to empty) is a more appropriate indicator of how quickly storage is recovered and can be used (along with climate data input to the model) as a predictor of long term capture efficiency.

By isolating these two most important predictive variables, a limited number of continuous simulation model runs, and associated results can be used to describe the expected long term performance of a wide range of BMP and/or site design types and configurations. For example, the results of a long term model simulation for a 0.5xDCV storage with 48-hour drawdown would be representative of a wide range of different BMP and/or site design configurations. The two examples would both be reliably represented by this single model run.

- Example 1: 10,000 cu-ft infiltration basin draining 10.2 acres of pavement (equates to 0.5DCV when 85th percentile rainfall is 0.6 inches), with 3-foot ponding depth and a design infiltration rate of 0.75 inches per hour (equates to 48-hour drawdown time).
- Example 2: 300 cu-ft of aggregate storage volume below the underdrain invert in a biofiltration with partial retention BMP with a tributary area of 0.367 acres of pavement (equates to 0.5DCV when 85th percentile rainfall is 0.5 inches), with an effective depth of 6 inches and a design infiltration rate of 0.125 in/hr. (equates to 48-hour drawdown time).

It can be seen that an infinite number of potential design combinations could be reflected by thissingle model run.

B.5.4.2 Modeling Methodology and Results

Three sets of continuous simulation runs were executed in the EPA SWMM using the default parameters in **Appendix G** and the Lake Wohlford rain gage to develop the nomographs that can be used to estimate the volume retention benefits from BMPs and/or site design BMPs.

- **Consistent drawdown runs**: Consistent drawdown runs were used to represent BMPs and/or site design elements that can be approximated as draining at a relatively consistent rate throughout a long term continuous simulation (e.g., infiltration, media filtration, orifice discharge). The template model setup developed for these runs included a tributary subcatchment draining to a storage unit of a given size (varied between runs) modeled with a drawdown rate (varied between runs) that was held constant throughout each simulation. Continuous rainfall-runoff processes were simulated to estimate the continuous runoff hydrograph. Routing through the storage unit was simulated to estimate the long term capture efficiency associated with the given configuration. The results from these runs are presented in **Figure B.4-1 in Appendix B.4.2**.

- **Evapotranspiration drawdown runs**: Evapotranspiration runs were used to represent BMPs and/or site design elements that drain via evapotranspiration processes, at rates that inherently vary with climatic factors throughout the year. The template model setup developed for these runs included a tributary subcatchment draining to a storage unit of a given size (varied between runs) modeled with a given stored water depth (varied between runs) that was drawn down at the applied evapotranspiration rate (varies on a monthly basis). Continuous rainfall-runoff processes were simulated to estimate the continuous runoff hydrograph. Routing through the storage unit was simulated to estimate the long term evapotranspiration loss associated with the given configuration. Results from these runs are presented in **Figure B.5-5**.

Dispersion runs: Dispersion runs were used to represent site design elements that cannot be simply divided into different storage units because water is dispersed in a thin layer and is acted upon by both infiltration and evapotranspiration processes. The template model setup developed for these runs included a tributary subcatchment draining to two broad, shallow storage units in series (area varied between runs to represent different proportions of pervious area receiving dispersion). The first storage unit was used to represent water stored in the "suction storage" of soil pores that did not freely drain via gravity. This was filled first and was drawn down at the rate established by evapotranspiration inputs. This storage unit also received flow from a "dummy catchment" with 100 percent imperviousness and zero depression storage; effectively representing precipitation directly on the dispersion area. The second storage unit had the same footprint as the first storage unit (i.e., equal to the size of the dispersion area) and received flow when the first storage unit overflowed. These storage units were effectively "stacked" in the model. This storage unit represented the freely drained pore storage (i.e., drained by gravity) in the amended media and any surface ponding in closed depressions. This storage unit was drained via Green-Ampt infiltration processes based on the assigned infiltration parameters (varied between runs). The depth of stored water in the first and second storage compartments was calculated based on the assumed depth of soil amendments (varied between runs) and typical amended soil properties. Continuous rainfall-runoff processes were simulated to estimate the runoff hydrograph. Routing through the storage units was simulated to estimate the long-term capture efficiency and the dispersion credit for the impervious area associated with the given configuration. Results from these runs are presented in **Figure B.5-6** (3" amendment); **Figure B.5-7** (6" amendment); **Figure B.5-8** (9" amendment); **Figure B.5-9** (12" amendment); **Figure B.5-10** (15" amendment) and **Figure B.5-11** (18" amendment).

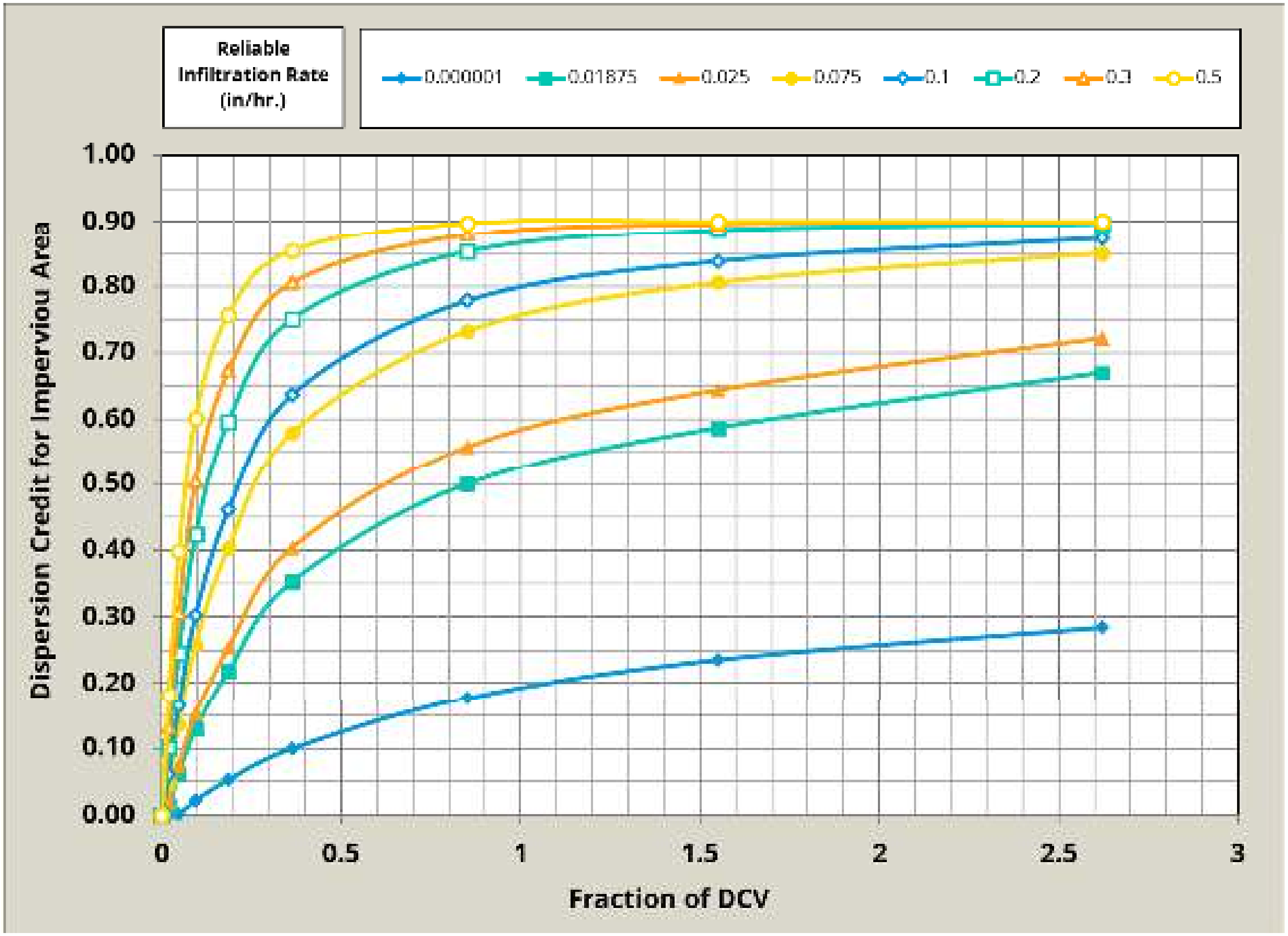

Figure B.5-5. Evapotranspiration Nomographs

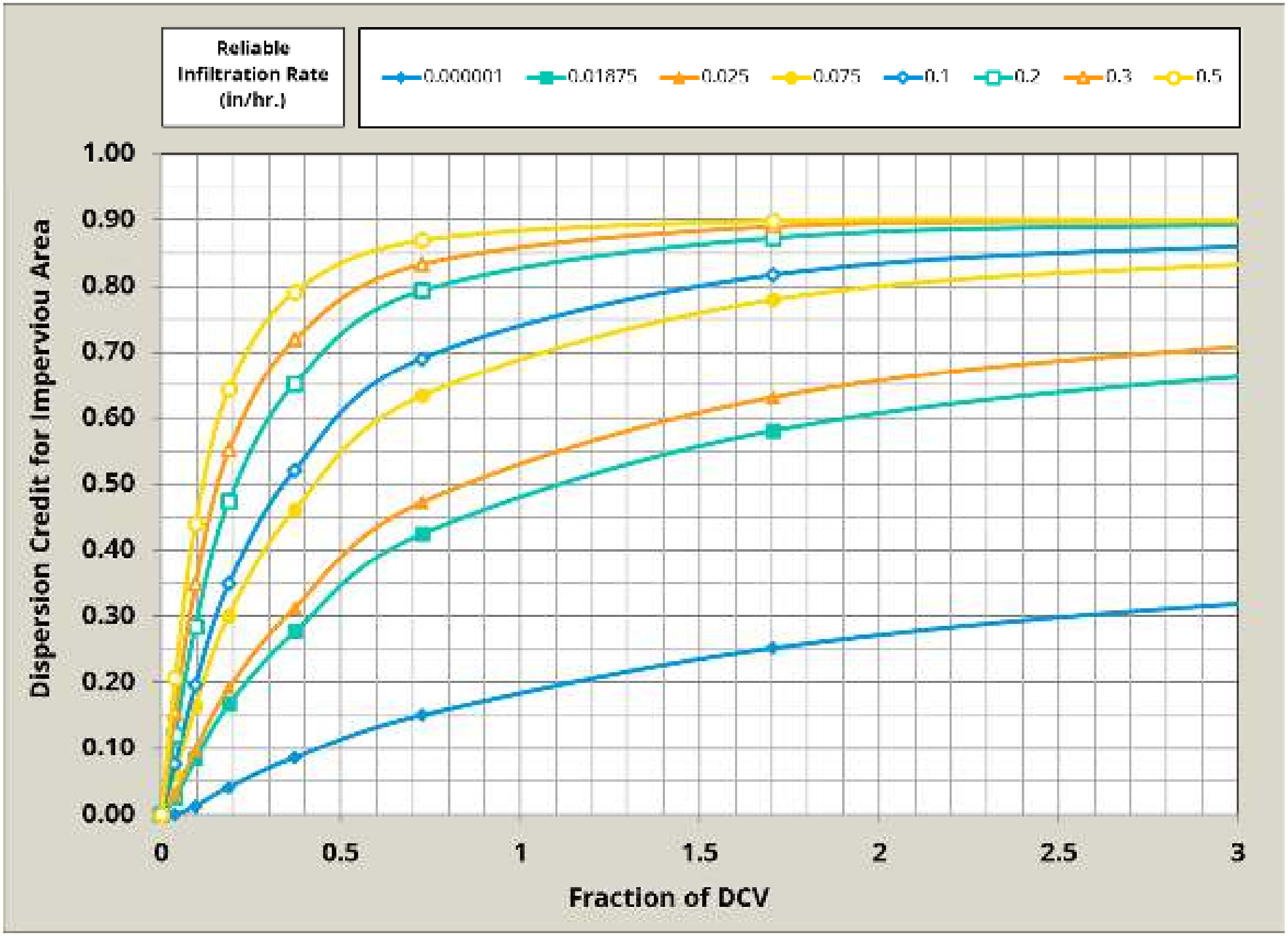

Figure B.5-6. 3" Amendment Dispersion Nomographs

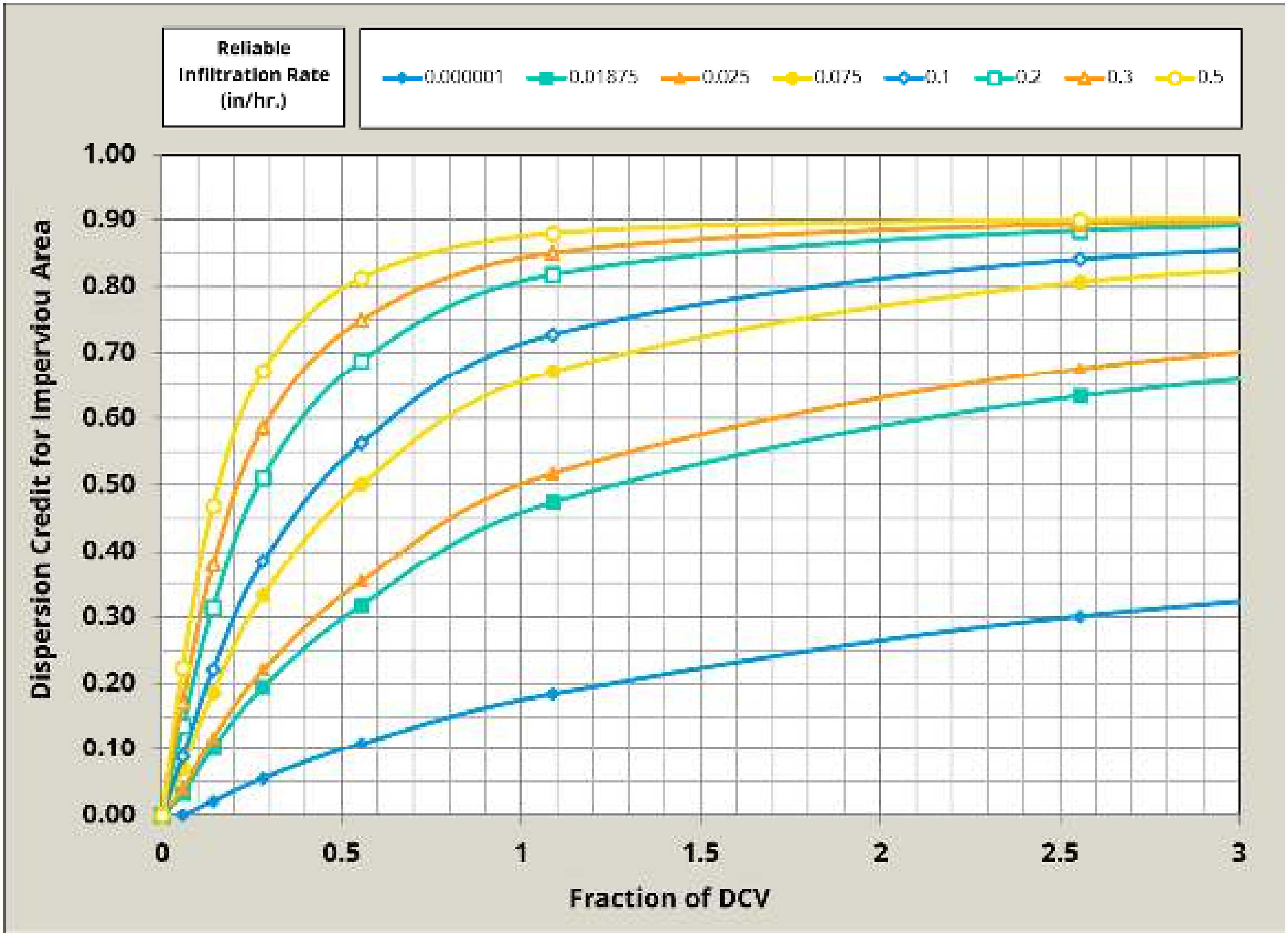

Figure B.5-7. 6" Amendment Dispersion Nomographs

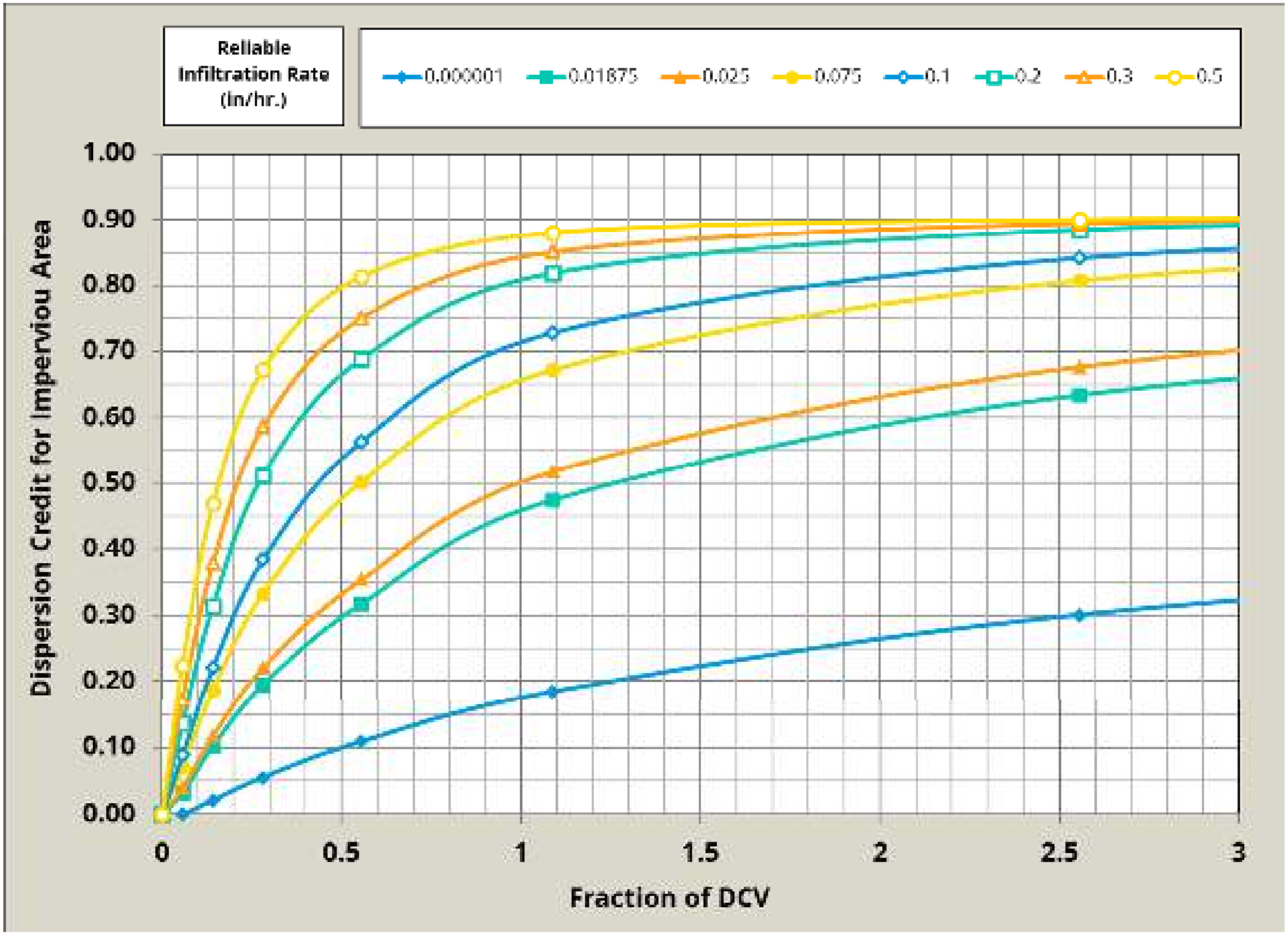

Figure B.5-8. 9" Amendment Dispersion Nomographs

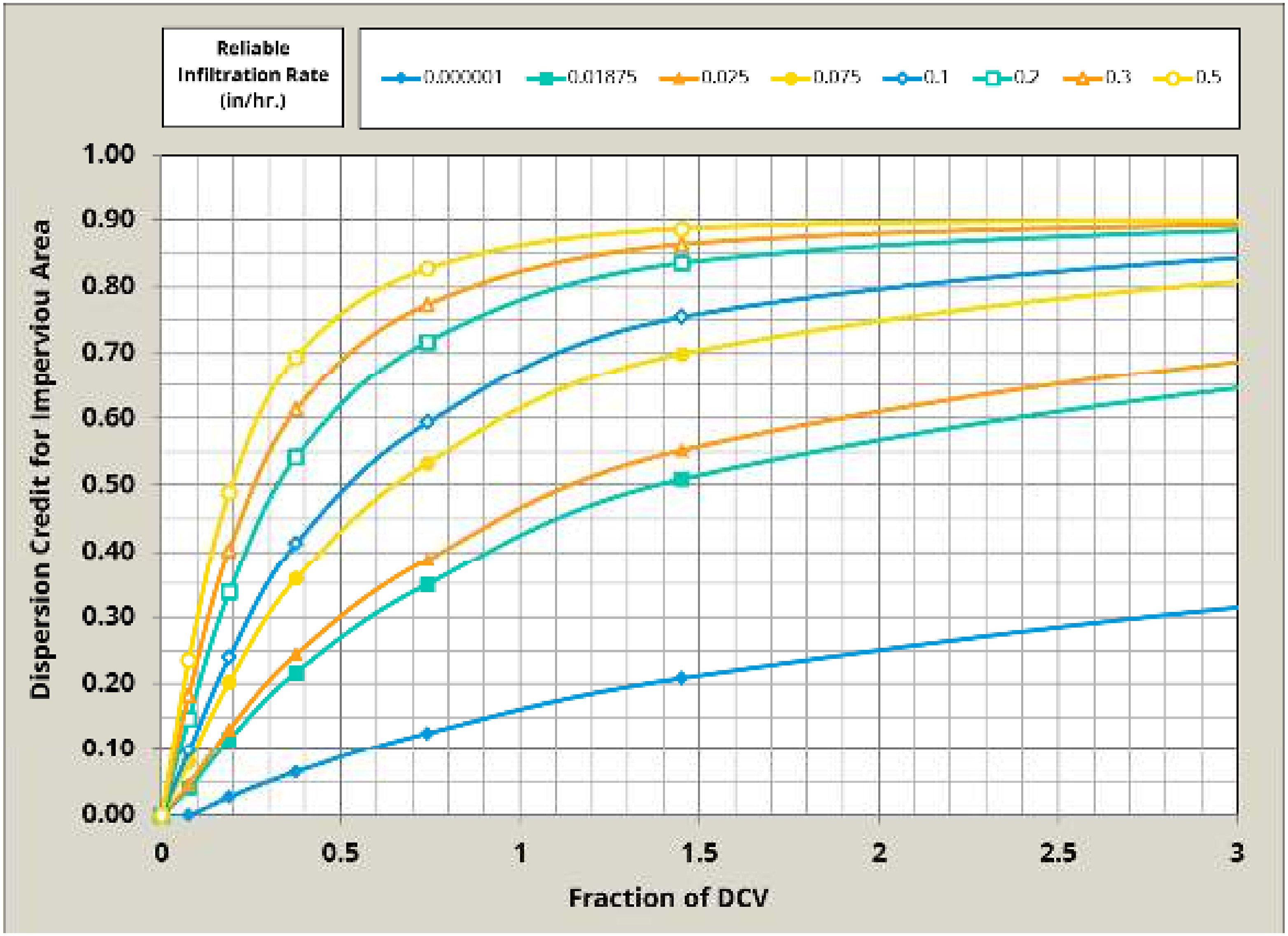

Figure B.5-9. 12" Amendment Dispersion Nomographs

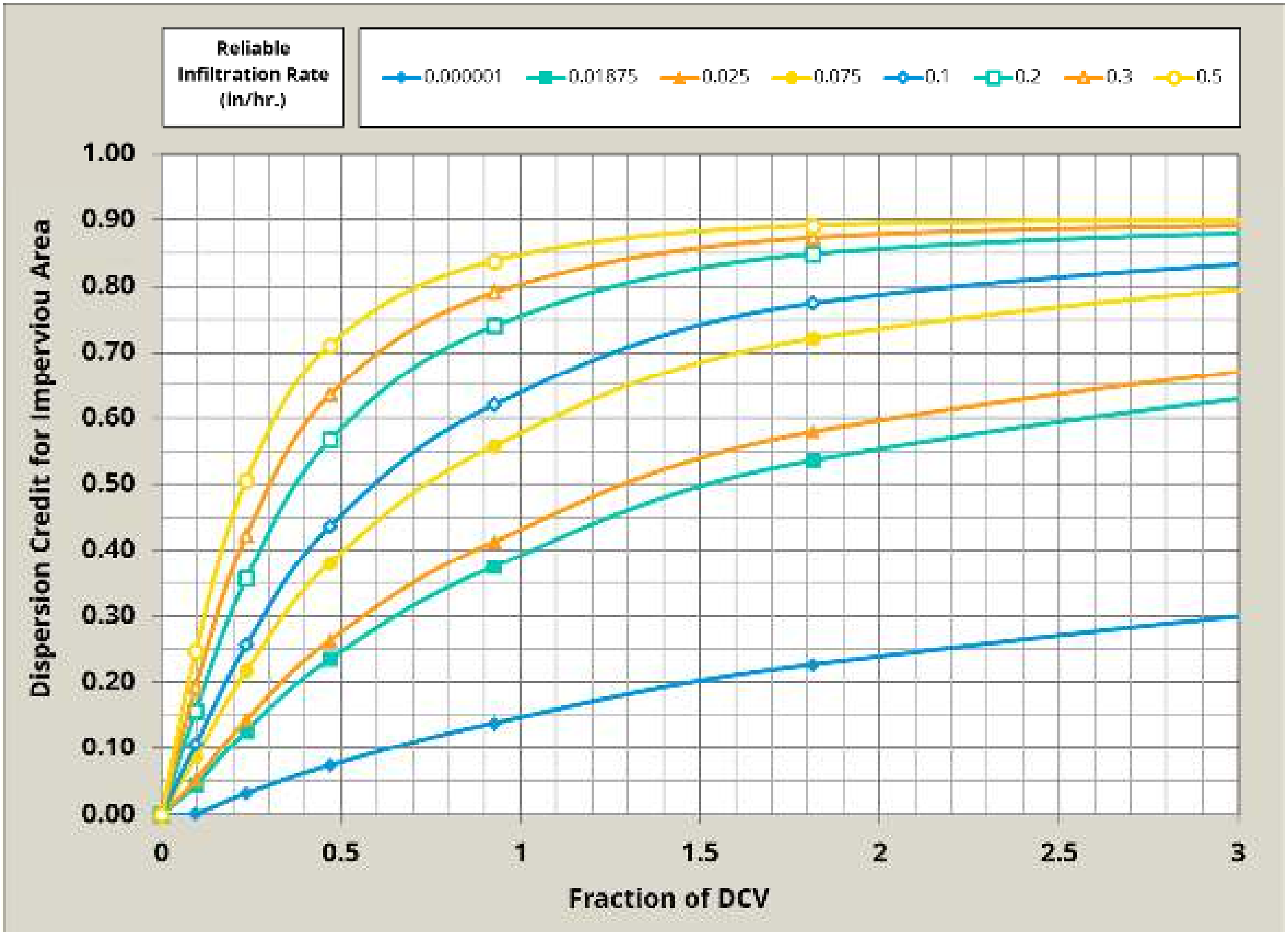

Figure B.5-10. 15" Amendment Dispersion Nomographs

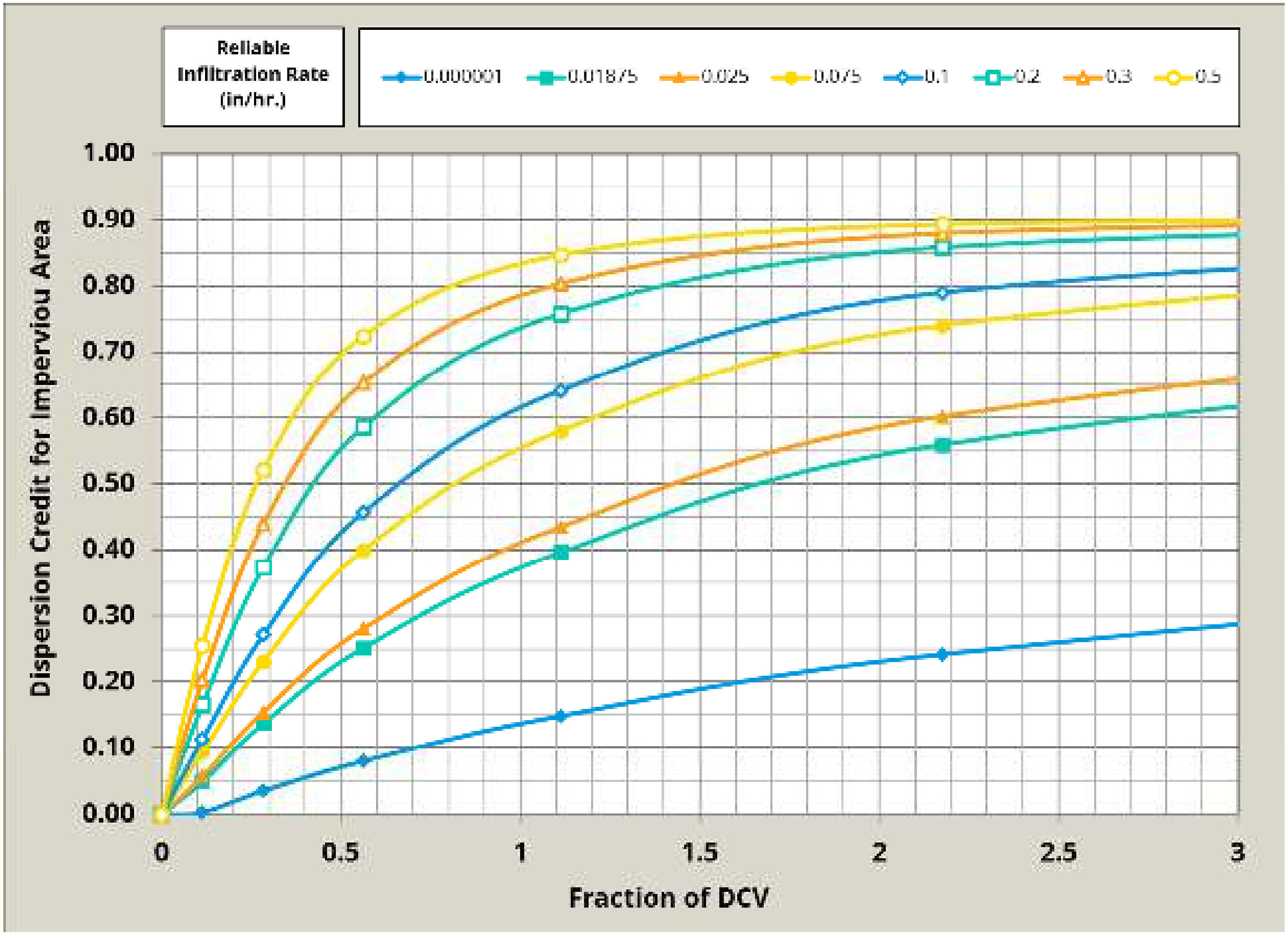

Figure B.5-11. 18" Amendment Dispersion Nomographs

B.6 Flow-Thru Treatment Control BMPs (for use with Alternative Compliance)

The following methodology shall be used for selecting and sizing onsite flow-thru treatment control BMPs. These BMPs are to be used only when the project is participating in an alternative compliance program. This methodology consists of three steps:

1) Determine the PDP most significant pollutants of concern (**Appendix B.6.1**).
2) Select a flow-thru treatment control BMP that treats the PDP most significant pollutants of concern and meets the pollutant control BMP treatment performance standard (**Appendix B.6.2**).
3) Size the selected flow-thru treatment control BMP (**Appendix B.6.3**).

Note:

- No pollutant control credit can be claimed for implementing flow-thru treatment control BMPs onsite. Project applicant must participate in alternative compliance for the entire portion of DCV that receives flow-thru treatment.
- Guidance in **Appendix B.6** is not applicable for selecting and crediting flow-thru BMPs for offsite storm water alternative compliance.

B.6.1 PDP Most Significant Pollutants of Concern

The following steps shall be followed to identify the PDP most significant pollutants of concern:

1. Compile the following information for the PDP and receiving water:
    a. Receiving water quality (including pollutants for which receiving waters are listed as impaired under the Clean Water Act section 303(d) List; refer to **Section 1.9**);
    b. Pollutants, stressors, and/or receiving water conditions that cause or contribute to the highest priority water quality conditions identified in the WQIP (refer to **Section 1.9**);
    c. Land use type(s) proposed by the PDP and the storm water pollutants associated with the PDP land use(s) (see Table B.6–1).
2. From the list of pollutants identified in Step 1 identify the most significant PDP pollutants of concern. A PDP could have multiple most significant pollutants of concerns and shall include the highest priority water quality condition identified in the watershed WQIP and pollutants anticipated to be present onsite/generated from land use.

TABLE B.6-1: Anticipated and Potential Pollutants Generated by Land Use Type

Priority Project Categories	General Pollutant Categories								
	Sediment	Nutrients	Heavy Metals	Organic Compounds	Trash & Debris	Oxygen Demanding Substances	Oil & Grease	Bacteria & Viruses	Pesticides
Detached Residential Development	X	X			X	X	X	X	X
Attached Residential Development	X	X			X	P(1)	P(2)	P	X
Commercial Development >one acre	P(1)	P(1)	X	P(2)	X	P(5)	X	P(3)	P(5)
Heavy Industry	X		X	X	X	X	X		
Automotive Repair Shops			X	X(4)(5)	X		X		
Restaurants					X	X	X	X	P(1)
Hillside Development >5,000 ft2	X	X			X	X	X		X
Parking Lots	P(1)	P(1)	X		X	P(1)	X		P(1)
Retail Gasoline Outlets			X	X	X	X	X		
Streets, Highways & Freeways	X	P(1)	X	X(4)	X	P(5)	X	X	P(1)

X = anticipated

P = potential

(1) A potential pollutant if landscaping exists onsite.

(2) A potential pollutant if the project includes uncovered parking areas.

(3) A potential pollutant if land use involves food or animal waste products.

(4) Including petroleum hydrocarbons.

(5) Including solvents.

B.6.2 Selection of Flow-Thru Treatment Control BMPs

The following steps shall be followed to select the appropriate flow-thru treatment control BMPs for the PDP:

1. For each PDP most significant pollutant of concern identify the grouping using Table B.6-2. Table B.6-2 is adopted from the Model SUSMP.
2. Select the flow-thru treatment control BMP based on the grouping of pollutants of concern that are identified to be most significant in Step 1. This section establishes the pollutant control BMP treatment performance standard to be met for each grouping of pollutants in order to meet the standards required by the MS4 permit and how an applicant can select a non-

proprietary or a proprietary BMP that meets the established performance standard. The grouping of pollutants of concern are:

a. Coarse Sediment and Trash (**Appendix B.6.2.1**)
b. Pollutants that tend to associate with fine particles during treatment (**Appendix B.6.2.2**)
c. Pollutants that tend to be dissolved following treatment (**Appendix B.6.2.3**)

TABLE B.6-2: Grouping of Potential Pollutants of Concern

Pollutant	Coarse Sediment and Trash	Suspended Sediment and Particulate-bound Pollutants[1]	Soluble-form Dominated Pollutants[2]
Sediment	X	X	
Nutrients			X
Heavy Metals		X	
Organic Compounds		X	
Trash & Debris	X		
Oxygen Demanding		X	
Bacteria		X	
Oil & Grease		X	
Pesticides		X	

[1] Pollutants in this category can be addressed to Medium or High effectiveness by effectively removing suspended sediments and associated particulate-bound pollutants. Some soluble forms of these pollutants will exist, however treatment mechanisms to address soluble pollutants are not necessary to remove these pollutants to a Medium or High effectiveness.

[2] Pollutants in this category are not typically addressed to a Medium or High level of effectiveness with particle and particulate-bound pollutant removal alone.

One flow-thru BMP can be used to satisfy the required pollutant control BMP treatment performance standard for the PDP most significant pollutants of concern. In some situations, it might be necessary to implement multiple flow-thru BMPs to satisfy the pollutant control BMP treatment performance standards. For example, a PDP has trash, nutrients and bacteria as the most significant pollutants of concern. If a vegetated filter strip is selected as a flow-thru BMP then it is anticipated to meet the performance standard in **Appendix B.6.2.2 and B.6.2.3** but would need a trash removal BMP to meet the pollutant control BMP treatment performance standard in **Appendix B.6.2.1** upstream of the vegetated filter strip. This could be achieved by fitting the inlets and/or outlets with racks or screens on to address trash.

B.6.2.1 Coarse Sediment and Trash

If coarse sediment and/or trash and debris are identified as a pollutant of concern for the PDP, then BMPs must be selected to capture and remove these pollutants from runoff. The BMPs described below can be effective in removing coarse sediment and/or trash. These devices must be sized to treat the flow rate estimated using **Worksheet B.6-1**. Applicant can only select BMPs that have High or Medium effectiveness.

Trash Racks and Screens [Coarse Sediment: Low effectiveness; Trash: Medium to High effectiveness] are simple devices that can prevent large debris and trash from entering storm drain infrastructure and/or ensure that trash and debris are retained with downstream BMPs. Trash racks and screens can be installed at inlets to the storm drain system, at the inflow line to a BMP, and/or on the outflow structure from the BMP. Trash racks and screens are commercially available in many sizes and configurations or can be designed and fabricated to meet specific project needs.

Hydrodynamic Separation Devices [Coarse Sediment: Medium to High effectiveness; Trash: Medium to High effectiveness] are devices that remove coarse sediment, trash, and other debris from incoming flows through a combination of screening, settlement, and centrifugal forces. The design of hydrodynamic devises varies widely, more specific information can be found by contacting individual vendors. A list of hydrodynamic separator products approved by the Washington State Technology Acceptance Protocol-Ecology protocol can be found at:

http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html.

Systems should be rated for "pretreatment" with a General Use Level Designation or provide results of field-scale testing indicating an equivalent level of performance.

Catch Basin Insert Baskets [Coarse Sediment: Low effectiveness; Trash: Medium effectiveness, if appropriately maintained] are manufactured filters, fabrics, or screens that are placed in inlets to remove trash and debris. The shape and configuration of catch basin inserts varies based on inlet type and configuration. Inserts are prone to clogging and bypass if large trash items are accumulated, and therefore require frequent observation and maintenance to remain effective. Systems with screen size small enough to retain coarse sediment will tend to clog rapidly and should be avoided.

Other Manufactured Particle Filtration Devices [Coarse Sediment: Medium to High effectiveness; Trash: Medium to High effectiveness] include a range of products such as cartridge filters, bag filters, and other configurations that address medium to coarse particles. Systems should be rated for "pretreatment" with a General Use Level Designation under the Technology Acceptance Protocol-Ecology program or provide results of field-scale testing indicating an equivalent level of performance.

<u>Note, any BMP that achieves Medium or High performance for suspended solids (See **Appendix B.6.2.2**) is also considered to address coarse sediments. However, some BMPs that address suspended solids do not retain trash (for example, swales and detention basins). These types of BMPs could be fitted with racks or screens on inlets or outlets to address trash.</u>

BMP Selection for Pretreatment: Devices that address both coarse sediment and trash can be used as pretreatment devices for other BMPs, such as infiltration BMPs. However, it is recommended that BMPs that meet the performance standard in **Appendix B.6.2.2** be used. A device with a "pretreatment" rating and General Use Level Designation under Technology Acceptance Protocol-

Ecology is required for pretreatment upstream of infiltration basins and underground galleries. Pretreatment may also be provided as presettling basins or forebays as part of a pollutant control BMP instead of implementing a specific pretreatment device for systems where maintenance access to the facility surface is possible (to address clogging), expected sediment load is not high, and appropriate factors of safety are included in design.

B.6.2.2 Suspended Sediment and Particulate-Bound Pollutants

Performance Standard

The pollutant treatment performance standard is shown in Table B.6-3. This performance standard is consistent with the Washington State Technology Acceptance Protocol-Ecology Basic Treatment Level and is also met by technologies receiving Phosphorus Treatment or Enhanced Treatment certification. This standard is based on pollutant removal performance for total suspended solids. Systems that provide effective TSS treatment also typically address trash, debris, and particulate bound pollutants and can serve as pre-treatment for offsite mitigation projects or for onsite infiltration BMPs.

Table B.6-3: Performance Standard for Flow-Thru Treatment Control

Influent Range	Criteria
20 – 100 mg/L TSS	Effluent goal ≤ 20 mg/L TSS
100 – 200 mg/L TSS	≥ 80% TSS removal
>200 mg/L TSS	> 80% TSS removal

Selecting Non-Proprietary BMPs

Table B.6-4 identifies the categories of non-proprietary BMPs that are considered to meet the pollutant treatment performance standard if designed to contemporary design standards[8]. BMP types with a "High" ranking should be considered before those with a "Medium" ranking. Statistical analysis by category from the International Stormwater BMP Database (also presented in Table B.6-4) indicates each of these BMP types (as a categorical group) meets or nearly meets the performance standard. The International Stormwater BMP Database includes historic as well as contemporary BMP studies; contemporary BMP designs in these categories are anticipated to meet or exceed this standard on average.

[8]Contemporary design standards refer to design standards that are reasonably consistent with the current state of practice and are based on desired outcomes that are reasonably consistent with the context of the MS4 Permit and this manual. For example, a detention basin that is designed solely to mitigate peak flow rates would not be considered a contemporary water quality BMP design because it is not consistent with the goal of water quality improvement. Current state of the practice recognizes that a drawdown time of 24 to 72 hours is typically needed to promote settling. For practical purposes, design standards can be considered "contemporary" if they have been published within the last 10 years, preferably in California or Washington State, and are specifically intended for storm water quality management.

Table B.6-4: Flow-Thru Treatment Control BMPs Meeting Performance Standard

List of Acceptable Flow-Thru Treatment Control BMPs	Statistical Analysis of International Stormwater BMP Database				Evaluation of Conformance to Performance Standard		
	Count In/Out	TSS Mean Influent, mg/L	TSS Mean Effluent[1], mg/L	Average Category Volume Reduct.	Volume-Adjusted Effluent Conc[2], mg/L	Volume-Adjusted Removal Efficiency[2]	Level of Attainment of Performance Standard (with rationale)
Vegetated Filter Strip	361/ 282	69	31	38%	19	72%	Medium, effluent < 20 mg/L after volume adjustment
Vegetated Swale	399/ 346	45	33	48%	17	61%	Medium, effluent < 20 mg/L after volume adjustment
Detention Basin	321/ 346	125	42	33%	28	77%	Medium, percent removal near 80% after volume adjustment
Sand Filter/ Media Bed Filter	381/ 358	95	19	NA[3]	19	80%	High, effluent and % removal meet criteria without adjustment
Lined Porous Pavement[4]	356/ 220	229	46	NA[3,4]	46	80%	High, % removal meets criteria without adjustment
Wet Pond	923/ 933	119	31	NA[3]	31	74%	Medium, percent removal near 80%

Source: 2014 BMP Performance Summaries and Statistical Appendices; 2010 Volume Performance Summary; available at: www.bmpdatabase.org

[1] A statistically significant difference between influent and effluent was detected at a p value of 0.05 for all categories.

[2] Estimates were adjusted to account for category-average volume reduction.

[3] Not Applicable as these BMPs are not designed for volume reduction and are anticipated to have very small incidental volume reduction.

4 The category presented in this table represents a lined system for flow-thru treatment purposes. Porous pavement for retention purposes is an infiltration BMP, not a flow-thru BMP. This table should not be consulted for porous pavement for infiltration.

Selecting Proprietary BMPs

Proprietary BMPs can be used if the BMP meets each of the following conditions:

1. **The proposed BMP meets the performance standard in Appendix B.6.2.2 as certified through third-party, field scale evaluation**. An active General Use Level Designation for Basic Treatment, Phosphorus Treatment or Enhanced Treatment under the Washington State Technology Acceptance Protocol-Ecology program is the preferred method of demonstrating that the performance standard is met. The list of certified technologies is updated as new

technologies are approved (link below). Technologies with Pilot Use Level Designation and Conditional Use Level Designations are not acceptable. Refer to: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html. Alternatively, other field scale verification of 80 percent TSS capture, such as through Technology Acceptance Reciprocity Partnership or New Jersey Corporation for Advance Testing may be acceptable. A list of field-scale verified technologies under Technology Acceptance Reciprocity Partnership Tier II and New Jersey Corporation for Advance Testing can be accessed at: http://www.njcat.org/verification-process/technology-verification-database.html (refer to field verified technologies only).

2. **The proposed BMP is designed and maintained in a manner consistent with its performance certifications (see explanation below)**. The applicant must demonstrate conclusively that the proposed application of the BMP is consistent with the basis of its certification/verification. Certifications or verifications issued by the Washington Technology Acceptance Protocol-Ecology program and the Technology Acceptance Reciprocity Partnership or New Jersey Corporation for Advance Testing programs are typically accompanied by a set of guidelines regarding appropriate design and maintenance conditions that would be consistent with the certification/verification. It is common for these approvals to specify the specific model of BMP, design capacity for given unit sizes, type of media that is the basis for approval, and/or other parameters.

3. The proposed BMP is acceptable at the discretion of the City Engineer. The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met. In determining the acceptability of a proprietary flow-thru treatment control BMP, the City Engineer should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by the City Engineer, a written explanation/reason will be provided to the applicant.

B.6.2.3 Soluble-form dominated Pollutants (Nutrients)

If nutrients are identified as a most significant pollutant of concern for the PDP, then BMPs must be selected to meet the performance standard described in **Appendix B.6.2.2** and must be selected to provide medium or high level of effectiveness for nutrient treatment as described in this section. The most common nutrient of concern in the San Diego region is nitrogen, therefore total nitrogen (TN) was used as the primary indicator of nutrient performance in storm water BMPs.

Selection of BMPs to address nutrients consists of two steps:

1. Determine if nutrients can be addressed via source control BMPs as described in Appendix E and Chapter 4. After applying source controls, if there are no remaining source areas for soluble nutrients, then this pollutant can be removed from the list of pollutants of concerns

for the purpose of selecting flow-thru treatment control BMPs. Particulate nutrients will be addressed by the performance standard in **Appendix B.6.2.2**.

2. If soluble nutrients cannot be fully addressed with source controls, then select a flow-thru treatment control BMPs that meets the performance criteria in Table B.6-5 or select from the nutrient-specific menu of treatment control BMPs in Table B.6-6.
    a. The performance standard for nitrogen removal (Table B.6-5) has been developed based on evaluation of the relative performance of available categories of non-proprietary BMPs.
    b. For proprietary BMPs, submit third party performance data indicating that the criteria in Table B.6-5 are met. The applicant may be required to provide additional studies and/or required to meet additional design criteria beyond the scope of this document in order to demonstrate that these criteria are met. In determining the acceptability of a proprietary flow-thru treatment control BMP, the City Engineer should consider, as applicable, (a) the data submitted; (b) representativeness of the data submitted; (c) consistency of the BMP performance claims with pollutant control objectives; certainty of the BMP performance claims; (d) for projects within the public right of way and/or public projects: maintenance requirements, cost of maintenance activities, relevant previous local experience with operation and maintenance of the BMP type, ability to continue to operate the system in event that the vending company is no longer operating as a business; and (e) other relevant factors. If a proposed BMP is not accepted by the City Engineer, a written explanation/reason will be provided to the applicant.

Table B.6-5: Performance Standard for Flow-Thru Treatment Control BMPs for Nutrient Treatment

Basis	Criteria
Treatment Basis	Comparison of mean influent and effluent indicates significant concentration reduction of TN approximately 40 percent or higher based on studies with representative influent concentrations
Combined Treatment and Volume Reduction Basis	Combination of concentration reduction and volume reduction yields TN mass removal of approximately 40 percent or higher based on studies with representative influent concentrations

Table B.6-6: Flow-Thru Treatment Control BMPs Meeting Nutrient Treatment Performance Standard

List of Acceptable Flow-Thru Treatment Control BMPs for Nutrients	Statistical Analysis of International Stormwater BMP Database				Evaluation of Conformance to Performance Standard		
	Count In/Out	TN Mean Influent, mg/L	TN Mean Effluent[1], mg/L	Average Category Volume Reduct.	Volume-Adjusted Effluent Conc[2],	Volume-Adjusted Removal	Level of Attainment of Performance Standard (with rationale)
Vegetated Filter Strip	138/ 122	1.53	1.37	38%	0.85	44%	Medium, if designed to include volume reduction processes
Detention Basin	90/ 89	2.34	2.01	33%	1.35	42%	Medium, if designed to include volume reduction processes
Wet Pond	397/ 425	2.12	1.33	NA	1.33	37%	Medium, best concentration reduction among BMP categories, but limited volume reduction

Source: 2014 BMP Performance Summaries and Statistical Appendices; 2010 Volume Performance Summary; available at: www.bmpdatabase.org

1 A statistically significant difference between influent and effluent was detected at a p value of 0.05 for all categories included.

2 Estimates were adjusted to account for category-average volume reduction.

B.6.3 Sizing Flow-Thru Treatment Control BMPs:

Flow-thru treatment control BMPs shall be sized to filter or treat the maximum flow rate of runoff produced from a rainfall intensity of 0.2 inch of rainfall per hour, for each hour of every storm event. The required flow-thru treatment rate should be adjusted for the portion of the DCV already retained or biofiltered onsite as described in Worksheet B.6-1. The following hydrologic method shall be used to calculate the flow rate to be filtered or treated:

$$\boldsymbol{Q = C \times i \times A}$$

Where:

Q = Design flow rate in cubic feet per second

C = Runoff factor, area-weighted estimate using Table B.1-1

I = Rainfall intensity of 0.2 in/hr.

A = Tributary area (acres) which includes the total area draining to the BMP, including any offsite or onsite areas that comingle with project runoff and drain to the BMP. Refer to Section 3.3.3 for additional guidance. Street projects consult Section 1.4.3.

Worksheet B.6-1: Flow-Thru Design Flows

Flow-thru Design Flows		Worksheet B.6-1		
1	DCV	DCV		cubic-feet
2	DCV retained	$DCV_{retained}$		cubic-feet
3	DCV biofiltered	$DCV_{biofiltered}$		cubic-feet
4	DCV requiring flow-thru (Line 1 – Line 2 – 0.67*Line 3)	$DCV_{flow\text{-}thru}$		cubic-feet
5	Adjustment factor (Line 4 / Line 1)*	AF=		unitless
6	Design rainfall intensity	i=	0.20	in/hr
7	Area tributary to BMP (s)	A=		acres
8	Area-weighted runoff factor (estimate using Appendix B.2)	C=		unitless
9	Calculate Flow Rate = AF x (C x i x A)	Q=		cfs

1) Adjustment factor shall be estimated considering only retention and biofiltration BMPs located upstream of flow-thru BMPs. That is, if the flow-thru BMP is upstream of the project's retention and biofiltration BMPs then the flow-thru BMP shall be sized using an adjustment factor of 1.
2) Volume based (e.g., dry extended detention basin) flow-thru treatment control BMPs shall be sized to the volume in Line 4 and flow based (e.g., vegetated swales) shall be sized to flow rate in Line 9. Sand filter and media filter can be designed either by volume in Line 4 or flow rate in Line 9.
3) Proprietary BMPs, if used, shall provide certified treatment capacity equal to or greater than the calculated flow rate in Line 9; certified treatment capacity per unit shall be consistent with third party certifications.