

Sizing Integrated Management Practices

Calculate minimum required sizes of IMPs on your site, and demonstrate your design complies with stormwater treatment or treatment-and-flow-control requirements.

Chapter 5 includes a procedure for site design and documentation using Low Impact Development techniques, including vegetated or grassy “dry” swales, bioretention areas, planter boxes, and other Integrated Management Practices (IMPs). Fact sheets in Attachment C-1 to Appendix C illustrate the IMP designs and list design criteria.

This Appendix—Appendix I—includes detailed procedures and sizing factors for calculating the required minimum size of IMPs. For each IMP design, factors are provided for:

- Treatment-only.
- Treatment-plus-flow-control.

Treatment-only IMPs are smaller and in some cases are simpler in design.

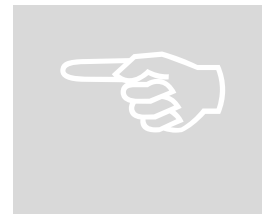
To determine whether flow-control requirements apply to your site, see Table 1-1 in Chapter 1. If flow-control requirements apply, review Appendix D to understand your options for meeting those requirements. The calculation procedures in this Appendix enable you to comply with flow-control requirements using “Option 2” in Appendix D. If flow-control requirements do not apply, or if you are using another option to meet flow-control requirements, then you may use the treatment-only factors to size your IMPs.

► IMP SIZING CALCULATOR VS. MANUAL CALCULATIONS

The Program has created an IMP Sizing Calculator to facilitate the iterative calculations needed to create an optimal site design. The calculator is a stand-alone





application and is available, along with instructions for its use, on the CCCWP’s C.3 web page (www.cccleanwater.org/construction/nd.php). In addition to performing calculations, the IMP Sizing Calculator formats calculation results into a summary report. The summary report can be attached to your Stormwater Control Plan submittal.

The formulas and procedures in this Appendix should be used to check and verify calculations made with the IMP Sizing Calculator. They can also be used without the sizing calculator to complete calculations and prepare a report suitable for submittal with your Stormwater Control Plan.



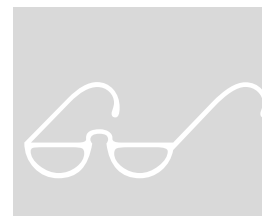
► HOW THE FORMULAS AND FACTORS WERE DEVELOPED

The treatment-only IMP sizing factors meet the hydraulic sizing criteria in Provision C.3.d of the NPDES permit.

I C O N K E Y	
	Helpful Tip
	Submittal Requirement
	Terms to Look Up
	References & Resources

The treatment-only sizing factor (0.04) for flow-through planters, in-ground (infiltration) planters, vegetated or grassy (“dry”) swales, and bioretention areas is based on a maximum design rainfall rate of 0.2 inches per hour and infiltration through the engineered sandy loam fill at a presumed minimum rate of 5 inches per hour. See Chapter 5.

The treatment-only sizing factors for direct infiltration IMPs—dry wells, infiltration trenches, and infiltration basins—are based on a minimum detention volume calculated using the California BMP method. Hourly rainfall records are used to continuously simulate runoff over 30 years. The IMPs are sized so that 80% of the total runoff during the simulation is detained and infiltrated. See Chapter 5 and Appendix H.



To develop treatment-and-flow-control sizing factors for IMPs, CCCWP consultants used 30 years of hourly rainfall data from Contra Costa gauges to continuously simulate runoff from a hypothetical one-acre site in (1) an undeveloped condition and (2) a completely impervious condition. Then, the consultants created computer models, including stage-discharge relationships, to

characterize the performance of each IMP design. Using an iterative procedure, the consultants found the minimum size of each facility that, when built into the impervious site, would match the frequency and intensity of pre-project flows during the simulation period. This process was repeated for the four different hydrologic soil groups (A, B, C, and D). The process was also

Key Abbreviations
 DMA=Drainage Management Area
 MAP = Mean Annual Precipitation
 IMP = Integrated Management Practice (treatment/detention facility)
 Also see the Glossary.

repeated for rain gauges in different parts of the County to characterize the relationship between IMP size and mean annual precipitation for each of the soil groups.

For more information, see Appendix D, including Attachment D-2, and the CCCWP's Hydrograph Modification Management Plan (available on the [C.3 web page](#)).

► SUMMARY OF THE CALCULATION PROCEDURE

You should be able to complete the needed calculations using only the project's site development plan, the information contained in this document, knowledge of the hydrologic soil group (A, B, C, or D) of the site soils, and the mean annual precipitation at the site. Appendix H includes isohyetal (rainfall depth) maps for this purpose.

The calculation requires the following steps:

Step 1 – Delineate distinct tributary Drainage Management Areas (DMAs)

Step 2 – Identify and list DMAs by type; identify runoff factors.

Step 3 – Select and lay out IMPs

Step 4 – Find Sizing Factor(s) for the IMPs selected and adjust for rainfall based on your site's location within Contra Costa County.

Step 5 – Calculate the minimum area (footprint) of each IMP.

Step 6 – Determine whether your layout can accommodate the minimum footprint of each IMP.

Iterate Steps 1-6 to obtain an optimal design.

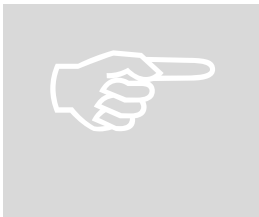
Step 7 – For flow control in Group C or D soils, compute the maximum underdrain flow rate and diameter of the flow-control orifices.

Step 8 – Tabulate your calculations and incorporate them into your Stormwater Control Plan.

► STEP 1: DELINEATE DRAINAGE MANAGEMENT AREAS

Drainage management areas (DMAs) are portions of a project site that drain to a common point. They must contain a single soil type and a uniform surface (e.g. landscaped or impervious). There are four types of DMAs:

1. Self-treating areas
2. Self-retaining areas
3. Areas draining to a self-retaining area
4. Areas draining to an IMP



See Chapter 5 (page 60) of the *Stormwater C.3 Guidebook, Third Edition*, for rules for delineating DMAs. Delineate the DMAs on your site plan or grading and drainage plan. All areas of the site must be within a DMA.

► STEP 2: IDENTIFY AND LIST DMAS BY TYPE; IDENTIFY RUNOFF FACTORS

For each of the DMAs, determine whether it will be self-treating, self-retaining, drains to a self-retaining area, or drains to an IMP. Group the DMAs by these types. For each DMA, find and tabulate the area, post-project surface, and soil type. Compile the information in a manner similar to Tables I-1 through I-4 below.

For self-treating and self-retaining areas, the area and cover type must be tabulated, but no calculations are necessary. For areas draining to a self-retaining area, no calculations need to be presented, but check to be sure the total amount of (square feet of tributary area × runoff factor) for all DMAs draining to a

TABLE I-1. Format for Tabulating Self-Treating Areas

<i>DMA Name</i>	<i>Area (square feet)</i>

TABLE I-2. Format for Tabulating Self-Retaining Areas

<i>DMA Name</i>	<i>Area (square feet)</i>

TABLE I-3. Format for Tabulating Areas Draining to Self-Retaining Areas

<i>DMA Name</i>	<i>Area (square feet)</i>	<i>Post-project surface type</i>	<i>Runoff factor</i>	<i>Receiving self-retaining DMA</i>	<i>Receiving self-retaining DMA Area (square feet)</i>

TABLE I-4. Format for Tabulating Areas Draining to IMPs

<i>DMA Name</i>	<i>Area (square feet)</i>	<i>Post-project surface type</i>	<i>Runoff factor</i>

receiving self-retaining area is no greater than a 1:1 ratio to the square footage of the receiving self-retaining area itself. A 2:1 ratio of impervious to receiving area may be used on sites not subject to flow-control requirements. See Chapter 5.

Use the surface types and corresponding runoff factors in Table I-5.

TABLE I-5. Runoff factors.

<i>Surface</i>	<i>Flow Control and Water Quality</i>	<i>Water Quality Only</i>
Roofs	1.0	1.0
Concrete	1.0	1.0
Grouted Unit Pavers	1.0	1.0
Pervious Concrete	0.6	0.1
Unit Pavers, Tight Pack	1.0	0.8
Unit Pavers with Gaps	0.8	0.3
Crushed Aggregate	0.6	0.1
Landscape, Group A Soil	0.1	0.1
Landscape, Group B Soil	0.3	0.1
Landscape, Group C Soil	0.5	0.1
Landscape, Group D Soil	0.7	0.1

► STEP 3: SELECT AND LAY OUT IMPs

After dividing the site into separate DMAs and determining the direction of drainage for each DMA, find appropriate locations for IMPs to receive runoff from DMAs draining to IMPs.

Select from the list of IMPs in Table I-6.

See Table 5-2 on page 71 and Table C-2 in Appendix C for guidance on selecting IMPs. Illustrations, designs, and design criteria for the IMPs are in Attachment C-1 to Appendix C.



Once you have laid out the IMPs, calculate the square footage you have set aside on your site plan for each IMP. Then, recalculate the square footage of each DMA to omit square footage now dedicated to IMPs.

► STEP 4: OBTAIN SIZING FACTORS AND RAIN ADJUSTMENT FOR EACH IMP

For each of the IMPs, obtain the appropriate sizing factor from Table I-6 or I-7. To size dry wells, infiltration trenches, and infiltration basins for treatment only, use the equations in Table I-8.

TABLE I-6. Sizing factors for treatment-plus-flow-control IMPs

<i>IMP</i>			<i>NRCS Soil Group</i>			
			<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
			<i>Square feet of IMP per square foot of tributary impervious area</i>			
In-Ground Planter			0.07	0.11	0.06	0.05
Flow-Through Planter			N/A	N/A	0.06	0.05
Bioretention Basin			0.10	0.15	0.08	0.06
Vegetated Grassy Swale ^A						
Bottom Width	Depth	Top Width	<i>Linear feet of swale per square foot of tributary impervious area</i>			
2.0	0.5	6.0	0.023	0.034	0.025	0.016
2.0	1.0	10.0	0.011	0.016	0.013	0.0080
2.0	1.5	14.0	0.0075	0.011	0.0080	0.0057
4.0	0.5	8.0	0.017	0.025	0.018	0.013
4.0	1.0	12.0	0.0086	0.013	0.0092	0.0063
4.0	1.5	16.0	0.0063	0.0092	0.0069	0.0046
6.0	0.5	10.0	0.014	0.020	0.015	0.011
6.0	1.0	14.0	0.0075	0.011	0.0075	0.0052
6.0	1.5	18.0	0.0057	0.0080	0.0057	0.0040
Dry Well			<i>Square feet of IMP per square foot of tributary impervious area</i>			
Depth = 3 ft			0.06	0.09	N/A	N/A
Depth = 4 ft			0.05	0.08	N/A	N/A
Depth = 5 ft			0.05	0.07	N/A	N/A
Depth = 6 ft			0.05	0.06	N/A	N/A
Infiltration Trench ^B						
Depth = 3 ft, Berm = 0.5 ft			0.06	0.10	N/A	N/A
Depth = 4 ft, Berm = 0.5 ft			0.06	0.09	N/A	N/A
Depth = 5 ft, Berm = 0.5 ft			0.05	0.08	N/A	N/A
Depth = 3 ft, Berm = 1 ft			0.06	0.09	N/A	N/A
Depth = 4 ft, Berm = 1 ft			0.05	0.08	N/A	N/A
Depth = 5 ft, Berm = 1 ft			0.05	0.07	N/A	N/A
Infiltration Basin						
Depth = 0.5 ft			0.10	0.16	N/A	N/A
Depth = 1 ft			0.07	0.12	N/A	N/A
Depth = 1.5 ft			0.06	0.09	N/A	N/A
Depth = 2 ft			0.06	0.08	N/A	N/A
Depth = 2.5 ft			0.05	0.07	N/A	N/A
Depth = 3 ft			0.05	0.06	N/A	N/A

A. Swales have 4H:1V side slopes.

B. Berm refers to the height of the berm surrounding an infiltration trench.

TABLE I-7. IMP sizing factors for treatment-only flow-through planters, in-ground (infiltration) planters, bioretention areas, and vegetated/grassy (“dry”) swales

<i>IMP</i>	<i>NRCS Soil Group</i>			
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
In-Ground (Infiltration) Planter	0.04	0.04	0.04	0.04
Flow-Through Planter	0.04	0.04	0.04	0.04
Bioretention Area	0.04	0.04	0.04	0.04
Vegetated/Grassy Swale (<i>area = top width × swale length = bottom width × 8 × depth × swale length</i>)				
All Configurations	0.04	0.04	0.04	0.04

TABLE I-8. Equations for calculating IMP area for treatment-only dry wells, infiltration trenches, and infiltration basins:

<p>Equation I-1 (for sizing for treatment only):</p> $UBSS = 0.0032 \times MAP + 0.0058$ <p>where UBSS is “unit basin storage size” in feet and MAP is the mean annual precipitation for the project site in inches (see Appendix H for an isohyetal map of Contra Costa County).</p>
<p>Equation I-2 (required storage volume for dry wells, infiltration trenches, and infiltration basins):</p> $Volume = [Tributary Area] \times UBSS$ <p>where the tributary area is expressed in square feet.</p>
<p>Equation I-3 (converting required storage volume to minimum footprint):</p> $IMP \text{ Area} = \frac{Volume}{Depth \times Porosity}$ <p>where Volume is expressed in cubic feet, depth is in feet, and IMP area is calculated as square feet. Porosity of gravel fill can be assumed to be 0.40. For infiltration basins (water ponded above ground surface), use porosity = 1.</p>

Sizing factors for treatment-only IMPs (Tables I-7 and I-8) do not require any adjustment for mean annual precipitation. (The factor for flow-through planters, in-ground (infiltration) planters, vegetated/grassy “dry” swales, and bioretention areas is a consistent 0.04 throughout the County, and the formulas for dry wells,

infiltration trenches, and infiltration basins already contain adjustments for mean annual precipitation.)

Sizing factors for treatment-plus-flow-control IMPs (Table I-6), however, must be adjusted to account for the effects of differing mean annual precipitation on pre-project and post-project runoff.

Use the equations below to compute the rainfall adjustment:

(Equation I-4)

$$\text{For Group A soils, } \textit{Rain Adjustment} = \frac{0.0009 \times (MAP_{\text{project site}} - 20.2) + 0.07}{0.07}$$

(Equation I-5)

$$\text{For Group B soils, } \textit{Rain Adjustment} = \frac{-0.0005 \times (MAP_{\text{project site}} - 20.2) + 0.11}{0.11}$$

(Equation I-6)

$$\text{For Group C soils, } \textit{Rain Adjustment} = \frac{-0.0022 \times (MAP_{\text{project site}} - 20.2) + 0.06}{0.06}$$

(Equation I-7)

$$\text{For Group D soils, } \textit{Rain Adjustment} = \frac{-0.0022 \times (MAP_{\text{project site}} - 20.2) + 0.05}{0.05}$$

► STEP 5: CALCULATE MINIMUM AREA (FOOTPRINT) OF EACH IMP

The minimum area of each IMP is found by summing up the contributions of each tributary DMA and multiplying by the adjusted sizing factor for the IMP.

Table I-9 extends the tabulation of DMAs draining to IMPs (Table I-4) to incorporate the following calculation of the required minimum area of the receiving IMP:

$$Min. IMP Size = \sum \left(\begin{matrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{matrix} \right) \times \left(\begin{matrix} IMP \\ Sizing \\ Factor \end{matrix} \right) \times \left(\begin{matrix} Rain \\ Adjustment \\ Factor \end{matrix} \right)$$

TABLE I-9. Format for Tabulating Areas Draining to IMPs and calculating minimum IMP size

DMA Name	DMA Area (square feet)	Post-project surface type	DMA Runoff factor	DMA Area x runoff factor	Soil Type:	IMP Name			
						IMP Sizing factor	Rainfall Adjustment Factor	Minimum IMP Size	Proposed IMP Size
<i>Total></i>									

► STEP 6: DETERMINE IF AVAILABLE SPACE FOR IMP IS ADEQUATE

Developing appropriately sized IMPs may be an iterative process. After computing the minimum IMP size using Steps 1 – 5, review the site plan to determine if the reserved IMP space is sufficient. If so, the planned IMPs will meet the Provision C.3 sizing requirements. If not, revise the plan accordingly. Revisions may include:

- Reducing the overall imperviousness of the project site
- Changing the grading and drainage to redirect some runoff toward other IMPs which may have excess capacity
- Making tributary landscaped DMAs self-treating or self-retaining
- Expanding IMP surface area

- Selecting a different IMP with a smaller sizing factor

► STEP 7: COMPUTE MAXIMUM UNDERDRAIN FLOW AND ORIFICE DIAMETER

This step applies only to treatment-and-flow-control flow-through planters, in-ground (infiltration) planters, vegetated/grassy “dry” swales, and bioretention areas built in Group C and D soils. IMPs in Group C and D soils require underdrains to function properly. Treatment-only IMPs are equipped with underdrains, but there is no restriction on the rate of outflow. For treatment-and-flow-control IMPs, the underdrain has a flow control orifice sized so that the rates and durations of flows do not exceed pre-project conditions.

Use the following equations to determine the maximum underdrain flow for Group C and D soils. Compute the total area draining to an IMP, use the equations to compute the maximum underdrain flow rate, and then apply the orifice equation to estimate the diameter of the flow control orifice.

For In-Ground and Flow-Through Planters:

(Equation I-8)

$$\text{Group C soils, Flow (cfs)} = \sum \left(\frac{\text{DMA}}{\text{Square Footage}} \right) \times \frac{0.093 \times (\text{MAP}_{\text{project site}} - 20.2) + 1.42}{10^6}$$

(Equation I-9)

$$\text{Group D soils, Flow (cfs)} = \sum \left(\frac{\text{DMA}}{\text{Square Footage}} \right) \times \frac{0.122 \times (\text{MAP}_{\text{project site}} - 20.2) + 1.85}{10^6}$$

For Vegetated Grassy Swales and Bioretention Basins:

(Equation I-10)

$$\text{Group C soils, Flow (cfs)} = \sum \left(\frac{\text{DMA}}{\text{Square Footage}} \right) \times \frac{0.233 \times (\text{MAP}_{\text{project site}} - 20.2) + 3.55}{10^6}$$

(Equation I-11)

$$\text{Group D soils, Flow (cfs)} = \sum \left(\frac{\text{DMA}}{\text{Square Footage}} \right) \times \frac{0.304 \times (\text{MAP}_{\text{project site}} - 20.2) + 4.64}{10^6}$$

Orifice Equation:

(Equation I-12)

$$\text{Orifice Area (in feet)} = \frac{\text{UnderdrainMaxFlow}}{c \times \sqrt{64.4 \times H}}$$

where c is the orifice coefficient, which may be approximated as 0.6. H is the height of the gravel layer above the orifice. The orifice area may be computed into a diameter, as follows:

(Equation I-13)

$$\text{Orifice Diameter (in inches)} = 12 \times \sqrt{\frac{4 \times \text{Orifice Area}}{\pi}}$$

► STEP 8: COMPLETE YOUR SUMMARY REPORT



Present your IMP sizing calculations in tabular form. Adapt the following format as appropriate to your project. Coordinate your presentation of DMAs and calculation of minimum IMP sizes with the Stormwater Control Plan exhibit (labeled to show delineation of DMAs and locations of IMPs) and with your Stormwater Control Plan report, which should incorporate a brief description of each DMA and each IMP.

Sum the total area of all DMAs and IMPs listed and show it is equal to the total project area. This step may include adjusting the square footage of some DMAs to account for area used for IMPs.

Format:

Project Name:

Project Location:

APN or Subdivision Number:

Total Project Area (square feet):

Mean Annual Precipitation at Project Site:

IMPs designed for (treatment only or treatment-and-flow-control):

I. Self-treating areas:

DMA Name *Area (square feet)*

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II. Self-retaining areas:

DMA Name *Area (square feet)*

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III. Areas draining to self-retaining areas:

<i>DMA Name</i>	<i>Post-project surface type</i>	<i>Runoff factor</i>	<i>Area (square feet)</i>	<i>Receiving self-retaining DMA</i>	<i>Receiving self-retaining DMA Area (square feet)</i>
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IV. Areas draining to IMPs (repeat for each IMP):

<i>DMA Name</i>	<i>DMA Area (square feet)</i>	<i>Post-project surface type</i>	<i>DMA Runoff factor</i>	<i>DMA Area × runoff factor</i>	<i>Soil Type:</i>	<i>IMP Name</i>					
						<i>IMP Sizing factor</i>	<i>Rainfall Adjustment Factor</i>	<i>Minimum IMP Size</i>	<i>Proposed IMP Size</i>	<i>Orifice Size</i>	
<i>Total</i>											

Attachment I-1: Example Sizing of Integrated Management Practices (Manual Calculations)

This simplified example is provided to illustrate the steps in Appendix I. The example is a 28,330-square-foot drive-through coffee shop with the following characteristics:

- Design is for treatment-plus-flow-control (for illustrative purposes only; flow-control requirements do not ordinarily apply to sites that create or replace less than one acre of impervious area.)
- Group “D” soils.
- Mean annual precipitation of is 15 inches.

► STEP 1: DELINEATE DRAINAGE MANAGEMENT AREAS

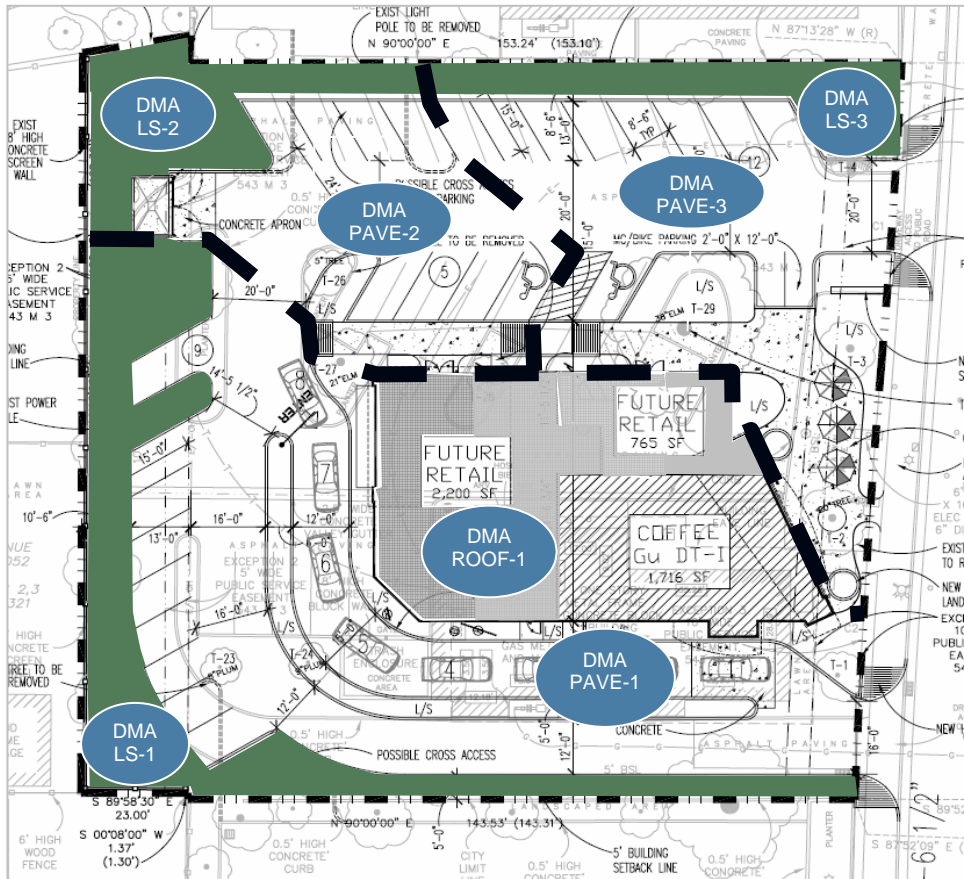


FIGURE I-1-1. EXAMPLE SITE DEVELOPMENT PLAN with DMAs Delineated

► STEP 2: IDENTIFY AND LIST DMAS BY TYPE; IDENTIFY RUNOFF FACTORS

All DMAs on the project site will be managed by draining stormwater runoff to appropriately sized IMPs.

TABLE I-1-1. DESCRIPTION OF DMAS for Example Site Development Plan

DMA	Area	Post-Project Surface Type	Runoff Factor
LS-1	6,205 ft ²	Landscape	0.7
PAVE-1	7,561 ft ²	Concrete/Asphalt	1.0
ROOF-1	4,681 ft ²	Roof	1.0
LS-2	1,112 ft ²	Landscape	0.7
PAVE-2	2,737 ft ²	Concrete/Asphalt	1.0
LS-3	1,207 ft ²	Landscape	0.7
PAVE-3	4,826 ft ²	Concrete/Asphalt	1.0
Total Site Area	28,330 ft ²		

► STEP 3: SELECT AND LAY OUT IMPs

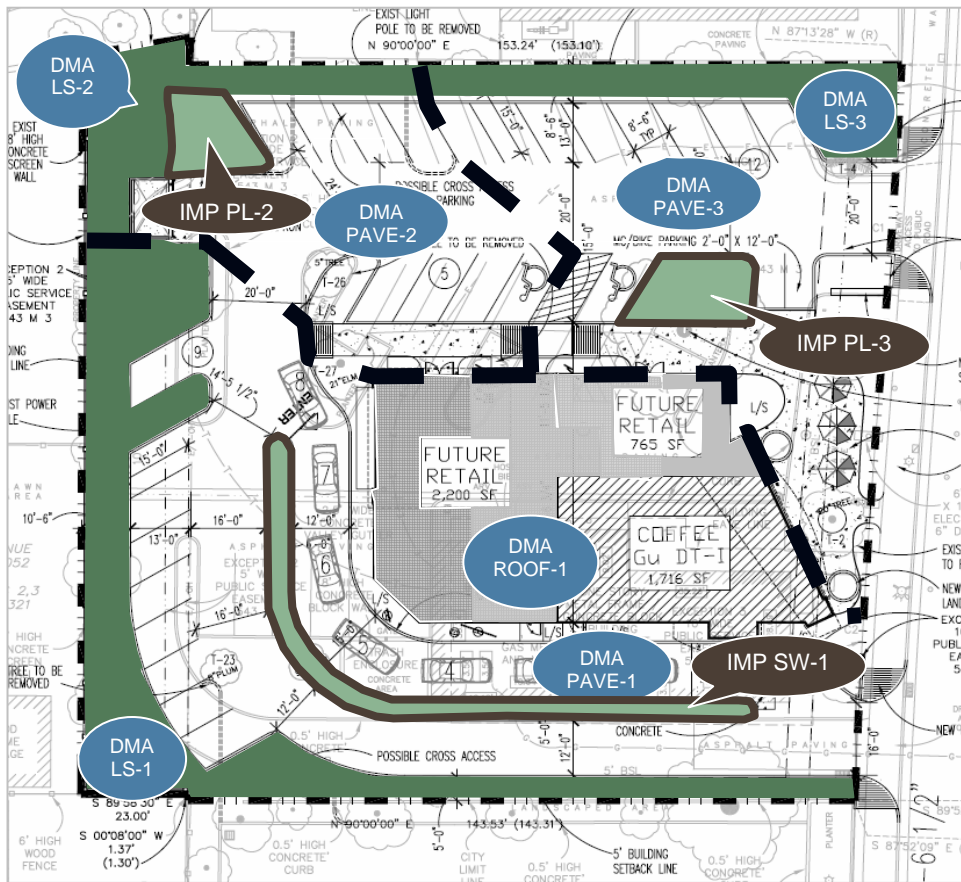


FIGURE I-1-2. EXAMPLE SITE DEVELOPMENT PLAN showing DMAs and IMPs.

► STEP 4: OBTAIN SIZING FACTORS AND RAINFALL ADJUSTMENT FOR EACH IMP

The sizing factor is obtained from Table I-6 (NRCS Soil Group is “D”). The rainfall adjustment for Group “D” soils is (Equation I-7), using an MAP of 15 inches:

$$Rain\ Adjustment = \frac{-0.0022 \times (MAP_{project\ site} - 20.2) + 0.05}{0.05} = 1.23$$

TABLE I-1-2. IMPS FOR EXAMPLE Site Development Plan

<i>IMP</i>	<i>IMP Type</i>	<i>Sizing Factor</i>	<i>Rainfall Adjustment</i>
SW-1	Vegetated Grassy Swale bottom width = 4' depth = 1.0'	0.0063 ^A	1.23
PL-2	In-Ground Planter	0.05 ^B	1.23
PL-3	In-Ground Planter	0.05 ^B	1.23

A. The vegetated grassy swale sizing factors represent the length of swale required to control 1 square foot of tributary impervious. For example, controlling 10,000 square feet of parking lot (in an area with a rainfall adjustment of 1.0) would require a 63 foot long swale with a 4 foot bottom width and 1 foot depth.

B. Sizing factors for the in-ground planter and all IMPs other than the vegetated grassy swale express the ratio of IMP area to the amount of impervious area controlled (again assuming the rainfall adjustment is 1.0). To control 10,000 square feet of impervious area would require an in-ground planter with an area of 500 square feet.

► STEP 5: CALCULATE MINIMUM AREA (FOOTPRINT) OF EACH IMP

TABLE I-1-3. TABULATION OF DMAS WITH IMPS and calculation of minimum IMP sizes

DMA Name	DMA Area (square feet)	Post-project surface type	DMA Runoff factor	DMA Area × runoff factor	Soil Type: IMP Name / Type			
					"D"	SW-1 / Vegetated Grassy Swale		
LS-1	6,205	Landscape	0.7	4,343.5	IMP Sizing factor	Rainfall Adjustment Factor	Minimum IMP Size	Proposed IMP Size
PAVE-1	7,561	Concrete/ Asphalt	1.0	7,561.0				
ROOF-1	4,681	Roof	1.0	4,681.0				
<i>Total</i>				16,585.5	0.0063	1.23	129 ft.	~80 ft.

DMA Name	DMA Area (square feet)	Post-project surface type	DMA Runoff factor	DMA Area × runoff factor	Soil Type: IMP Name / Type			
					"D"	PL-2 / In-Ground Planter		
LS-2	1,112	Landscape	0.7	778.4	IMP Sizing factor	Rainfall Adjustment Factor	Minimum IMP Size	Proposed IMP Size
PAVE-2	2,737	Concrete/ Asphalt	1.0	2,737.0				
<i>Total</i>				3,515.4	0.05	1.23	216 sf	~150 sf

DMA Name	DMA Area (square feet)	Post-project surface type	DMA Runoff factor	DMA Area × runoff factor	Soil Type: IMP Name / Type			
					"D"	PL-3 / In-Ground Planter		
LS-3	1,207	Landscape	0.7	844.9	IMP Sizing factor	Rainfall Adjustment Factor	Minimum IMP Size	Proposed IMP Size
PAVE-3	4,826	Concrete/ Asphalt	1.0	4,826.0				
<i>Total</i>				5,670.9	0.05	1.23	349 sf	~250 sf

► STEP 6: DETERMINE IF AVAILABLE SPACE FOR IMP IS ADEQUATE

As shown in Table I-1-3, the space allocated to each of the three IMPs is inadequate for this design. Solutions might include:

- Make DMAs LS-1, LS-2, and LS-3 self-treating or self-retaining.
- Make Swale SW-1 an infiltration planter instead (smaller sizing factor).
- Expand the area allocated to each IMP.
- Use another option for compliance with flow-control requirements, and use the IMPs for treatment only.

In Step 8, a completed tabulation is shown for a revised site design with landscaped areas LS-1, LS-2, and LS-3 made self-retaining, an infiltration planter substituted for Swale SW-1, and the IMPs resized.

► STEP 7: COMPUTE MAXIMUM UNDERDRAIN FLOW AND ORIFICE DIAMETER

Note the calculations for underdrain flow and orifice diameter are related to the tributary area and soil type draining to an IMP. The orifice slowly meters out captured stormwater to help the mitigated post-project site design more closely match the pre-project runoff conditions.

For Swale SW-1, use Equation I-11:

$$Flow (cfs) = \sum \left(\frac{DMA}{Square\ Footage} \right) \times \frac{0.304 \times (MAP_{project\ site} - 20.2) + 4.64}{10^6}$$

For Planter Boxes PL-2 and PL-3, use Equation I-9:

$$Flow (cfs) = \sum \left(\frac{DMA}{Square\ Footage} \right) \times \frac{0.122 \times (MAP_{project\ site} - 20.2) + 1.85}{10^6}$$

Determine the orifice area using Equation I-12:

$$Orifice\ Area\ (in\ feet) = \frac{UnderdrainMaxFlow}{c \times \sqrt{64.4 \times H}}$$

where H is the specified depth of the gravel layer (see the fact sheets—Attachment C-1 to Appendix C), minus 0.5 feet.

Then use Equation I-13 to calculate the orifice diameter:

$$\text{Orifice Diameter (in inches)} = 12 \times \sqrt{\frac{4 \times \text{Orifice Area}}{\pi}}$$

TABLE I-1-4. SUMMARY OF EXAMPLE CALCULATIONS for flow-control orifices

<i>IMP</i>	<i>IMP Type</i>	<i>Maximum allowable underdrain flow (gfs)</i>	<i>H, height of gravel layer above orifice (ft)</i>	<i>Orifice area (ft²)</i>	<i>Orifice diameter (in.)</i>
SW-1	Vegetated/grassy swale	0.057	2.0	0.0083	1.23
PL-2	In-ground (infiltration) Planter	0.0047	1.5	0.00080	0.38
PL-3	In-ground (infiltration) Planter	0.018	1.5	0.0031	0.76

► STEP 8: COMPLETE YOUR SUMMARY REPORT

As described in Step 6, the following example summary report incorporates the following changes from the above example:

- LS-1, LS-2, and LS-3 made self-retaining
- infiltration planter PL-1 substituted for Swale SW-1
- IMPs made larger

In this summary report, the square footage of the DMAs have been adjusted to account for areas now allocated to IMPs.

Summary Report

Project Name: Coffee Shop Example

Project Location: 123 Main Street

APN or Subdivision Number: APN 00-0000-00

Total Project Area (square feet): 28,330

Mean Annual Precipitation at Project Site: 15 inches

IMPs designed for: Treatment and flow control

I. Self-treating areas:

DMA Name *Area (square feet)*

(none)	
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II. Self-retaining areas:

DMA Name *Area (square feet)*

LS-1	6,205
LS-2	1,112
LS-3	1,207
Total	8,524

III. Areas draining to self-retaining areas:

DMA Name *Post-project surface type* *Runoff factor* *Area (square feet)* *Receiving self-retaining DMA* *Receiving self-retaining DMA Area (square feet)*

(none)					
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IV. Areas Draining to IMPs

DMA Name	DMA Area (square feet)	Post-project surface type	DMA Runoff factor	DMA Area × runoff factor	Soil Type:		IMP Name		
					"D"	PL-1			
PAVE-1	6,801	Concrete/ Asphalt	1.0	6,801.0	IMP Sizing factor	Rainfall Adjustment Factor	Minimum IMP Size	Proposed IMP Size	Orifice diameter
ROOF-1	4,681	Roof	1.0	4,681.0					
<i>Total</i>				11,482.0	0.05	1.23	705 sf	760 sf	.66 in

DMA Name	DMA Area (square feet)	Post-project surface type	DMA Runoff factor	DMA Area × runoff factor	Soil Type:		IMP Name		
					"D"	PL-2			
PAVE-2	2,557	Concrete/ Asphalt	1.0	2,557.0	IMP Sizing factor	Rainfall Adjustment Factor	Minimum IMP Size	Proposed IMP Size	Orifice diameter
<i>Total</i>				2,557.0					

DMA Name	DMA Area (square feet)	Post-project surface type	DMA Runoff factor	DMA Area × runoff factor	Soil Type:		IMP Name		
					"D"	PL-3			
PAVE-3	4,526	Concrete/ Asphalt	1.0	4,526.0	IMP Sizing factor	Rainfall Adjustment Factor	Minimum IMP Size	Proposed IMP Size	Orifice diameter
<i>Total</i>				4,526.0					

V. Tabulation of Site Areas

Total Area of DMAs draining to IMPs	18,565
Total Area of Self-Retaining DMAS	8,524
Total Area of IMPs	1,240
Total Area of Site	28,329