Central Coast Region
Stormwater Control Measure Sizing Calculator

Introduction and Instructions

Version: 3/28/2017

Software Features and Notes

- Calculator is a MS Excel workbook with VBA code to guide data entry and hydraulic calculations
  - ***Allow "Macros" when opening***
- Worksheets are "protected" to prevent changes in format, row and column locations, etc., and to protect embedded equations

```
'----------------------------------------
'Runoff Retention option
'----------------------------------------

    '-----------------------------------------------
    'Prepare an SBUH model for each active SCM
    '-----------------------------------------------
    'Switch to "SBUH Model" tab and delete all but the first SBUH mode
    Worksheets("SBUH Model").Activate
    Columns("R:XFD").Delete

    'Count the number of SCMs that receive flow from DMAs
    ActiveSCM_Count = 0
    For i = 1 To nSCMrows
        If Worksheets("Project Information").Cells(SCMcellUL.Row + (i
            ActiveSCM_Count = ActiveSCM_Count + 1
        End If
    Next
    'MsgBox ActiveSCM_Count & " SCMs connected to DMAs"

    If ActiveSCM_Count = 0 Then
        MsgBox "No SCMs have been connected to DMAs. Please revise inp
        Worksheets("Project Information").Activate
        Cells(1, 1).Select
        Exit Sub
    End If
```

- Cells are color-shaded to match their use:

yellow = data entry

Name
DMA #1
DMA #2

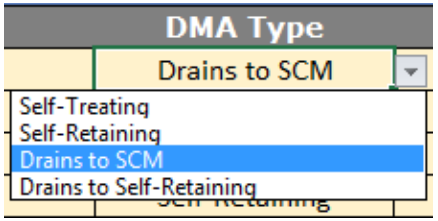
blue = generated results

Min. Required Storage Vol. (ft3)
455
109

grayed-out = not used

Surface Type

- Combo box/drop down lists are used wherever possible to guide data entry values:



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Software Features and Notes (Cont.)

- Calculator contains four worksheets:
  1. Project Information:
     - Project site, DMA, SCM characterization and results summary
  2. SBUH Model:
     - Location where model calculations are performed
  3. SCS, SBUH Equations:
     - Reference equations used by Calculator
  4. Lookups, Constants:
     - Values used in drop down lists and equations

Core of the user interface: Described in detail over the next 8 slides

Background calculations: Described in the final 3 slides

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Project Information Worksheet Overview

Central Coast Region Stormwater Control Measure Sizing Calculator

Version: 3/28/2017

1. Project Information

Project name:	Test Project - Santa Barbara
Project location:	Santa Barbara
Tier 2/Tier 3:	Tier 3 - Retention
Design rainfall depth (in):	2.0
Total project area (ft2):	32100
Total DMA area (ft2):	30000
Total new impervious area (ft2):	21000
Total replaced impervious within a USA (ft2):	0
Total replaced impervious not in a USA (ft2):	3000
Total pervious/landscape area (ft2):	6000
Total SCM area (ft2):	2100

Enter project site location and characteristics using drainage planning documents

2. DMA Characterization

Add DMA Row | Remove DMA Row

Name	DMA Type	Area (ft2)	Surface Type	New, Replaced?	Connection
DMA-1	Drains to SCM	3000	Concrete or asphalt	Replaced	SCM-1
DMA-2	Drains to Self-Retaining	10000	Roof		DMA - SRA#1
DMA-3	Drains to SCM	11000	Roof	New	SCM-2
DMA - SRA#1	Self-Retaining	6000			

DMA Summary Area

Total DMA area (ft2):	30000
New impervious area (ft2):	21000
Replaced impervious within a USA (ft2):	0
Replaced impervious not in a USA (ft2):	3000
Total pervious/landscape area (ft2):	6000

Define Drainage Management Areas. Iteratively add/remove and modify their characteristics

3. SCM Characterization

Add SCM Row | Remove SCM Row

Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)	Flow Control Orifice?	Reservoir Depth (in)
SCM-1	Bioretention	1	HSG C/D	0.25	1000	No	
SCM-2	Bioretention	1	HSG C/D	0.25	1100	Yes	6

Define Stormwater Control Measure characteristics. Iteratively test different configurations

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Project Information Overview (Cont.)

After DMAs and SCMs are defined, click to launch sizing calculations

4. Run SBUH Model

Launch Model

5. SCM Minimum Sizing Requirements

SCM Name	Min. Required Storage Vol. (ft3)	Depth Below Underdrain (ft)	Drain Time (hours)	Orifice Diameter (in)
SCM-1	440	1.00	0.0	
SCM-2	849	1.93	30.9	0.25

Calculator runs SBUH model and provides min. volume, depth and drainage time for each SCM

6. Self-Retaining Area Sizing Checks

Self-Retaining DMA Name	Self-Retaining DMA Area (ft2)	Tributary DMA Name(s)	Eff. Tributary DMA Area (ft2)	Effective Tributary / SRA Area Ratio
DMA - SRA#1	6000	DMA-2	10000	1.67

Calculator tracks connections and tributary area ratio for each self-retaining area

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Project Information Table

1. Project Information	
Project name:	Test Project - Santa Barbara
Project location:	Santa Barbara
Tier 2/Tier 3:	Tier 3 - Retention
Design rainfall depth (in):	2.0
Total project area (ft2):	32100
Total DMA area (ft2):	30000
Total new impervious area (ft2):	21000
Total replaced impervious within a USA (ft2):	0
Total replaced impervious not in a USA (ft2):	3000
Total pervious/landscape area (ft2):	6000
Total SCM area (ft2):	2100

Enter project name and location

Select: "Tier 2 – Treatment," "Tier 2 – Storage" or "Tier 3 – Retention"

Select design rainfall depth for project area

Summarize values from your drainage plan in the yellow cells. Calculator will compare these values to the DMAs you enter later.

Note: Self-retaining areas should be included in the "total pervious/landscape area" row

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DMA Characteristics Table

Add or remove DMAs here: not by manually inserting/deleting rows

2. DMA Characterization — Add DMA Row | Remove DMA Row

Name	DMA Type	Area (ft2)	Surface Type	New, Replaced?	Connection
DMA-1	Drains to SCM	3000	Concrete or asphalt	Replaced	SCM-1
DMA-2	Drains to Self-Retaining	10000	Roof		DMA - SRA#1
DMA-3	Drains to SCM	11000	Roof	New	SCM-2
DMA - SRA#1	Self-Retaining	6000			

Provide descriptive name

Select:
1) Self-Treating
2) Self-Retaining
3) Drains to SCM
4) Drains to Self-Retaining

Enter DMA Area

Select:
1) Roof
2) Concrete/asphalt
3) Grouted unit pavers
4) Pervious concrete
5) Porous asphalt
6) Unit pavers in sand
7) Open/porous pavers
8) Crushed aggregate
9) Turfblock
10) Landscape

For impervious areas, select:
1) New
2) Replaced
3) Replaced in an Urban Sustainability Area

Select DMA connection for “Drains to SCM” and “Drains to Self-Retaining” DMA types:

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DMA Summary Area and Data Check

- Calculator summarizes DMA impervious and pervious area types

Calculator flags any values that differ from Project Information values by more than 2 percent

DMA Summary Area		
Total DMA area (ft2):	30000	
New impervious area (ft2):	21000	*Check DMA table areas against plan sheet areas*
Replaced impervious within a USA (ft2):	0	
Replaced impervious not in a USA (ft2):	3000	*Check DMA table areas against plan sheet areas*
Total pervious/landscape area (ft2):	6000	

Values are automatically computed from information entered in the DMA Characteristics table

SCM Characteristics Table

Add or remove SCMs here: not by manually inserting/deleting rows

3. SCM Characterization			Add SCM Row / Remove SCM Row			Flow Control	Reservoir
Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)	Orifice?	Depth (in)
SCM-1	Bioretention	1	HSG C/D	0.25	1000	No	
SCM-2	Bioretention	1	HSG C/D	0.25	1100	Yes	6

Provide descriptive name

Select:
1) Direct Infiltration
2) Bioretention

Safely factor is computed

Select:
1) HSG A/B
2) HSG C/D
3) Site-specific

Reads selection on the left:
A/B = 0.75 in/hr
C/D = 0.25 in/hr
Site-specific = user-provided

Enter SCM plan area

Enter flow control orifice and reservoir information

Notes:

- For Tier 2 projects:
  - *Bioretention* applies to "Tier 2 – Treatment" projects; SCM plan area equals 4 percent of tributary area
  - *Direct Infiltration* applies to "Tier 2 – Storage" projects; can be used to simulate bioretention + buried vault facilities; SCM volume computed by SBUH model → make sure to enter 85th percentile rain
- You will need to enter SCMs here before you can "connect" DMAs to them
- You can iteratively modify SCM characteristics to test design concepts and fine tune the design

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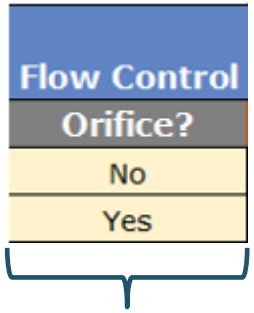
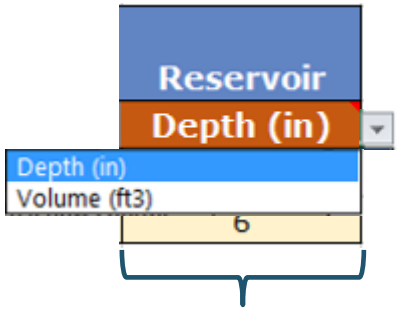
Effect of Flow Control Orifice

Background:

1. SCM designs with a flow control orifice can reduce the plan area and/or storage volume
2. The flow control orifice promotes efficient water storage by allowing water to accumulate in the bioretention soils and surface reservoir, which encourages more water to infiltrate into the soils surrounding the SCM
3. The SCM Sizing Calculator computes SCM volume using an SBUH model and then applies volume reductions that were developed using continuous simulation modeling



Select “Yes” or “No” Only available for bioretention



Specify reservoir size in depth or volume (depth <= 12 inches)

Pros	Cons
Reduces SCM storage volume	Requires additional engineering design
Reduces SCM plan area	Additional cost for outlet structure
Standard design allows O&M	Need maintenance strategy/process
Bioretention orifices have record of reliability	

Design consideration:

- Volume reductions are most beneficial for large facilities in space-constrained areas
  - Additional complexity/cost of outlet structure may not pencil out for small facilities

Launching Calculations and Viewing Results

4. Run SBUH Model

Launch Model

Click here after you have entered/updated all DMAs and SCMs. Software runs SBUH model for each connected SCM.

5. SCM Minimum Sizing Requirements

SCM Name	Min. Required Storage Vol. (ft3)	Depth Below Underdrain (ft)	Drain Time (hours)	Orifice Diameter (in)
SCM-1	440	1.00	0.0	
SCM-2	849	1.93	30.9	0.25

Model results, minimum sizing is reported here.

Note: Drain Time = 0 means the bioretention is dry before the 24 storm has ended (exfiltration > inflow)

6. Self-Retaining Area Sizing Checks

Self-Retaining DMA Name	Self-Retaining DMA Area (ft2)	Tributary DMA Name(s)	Eff. Tributary DMA Area (ft2)	Effective Tributary / SRA Area Ratio
DMA - SRA#1	6000	DMA-2	10000	1.67

Self-Retaining Area tributary connections are reported here. If the Tributary Area Ratio > 2 the cells turns red.

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SBUH Model Worksheet

Yellow-shaded cells are copied from “Project Information” sheet

Blue-shaded cells contains results that are copied to the “Project Information” sheet

SCM-1

SBUH Parameters:

Design rainfall depth (in) =	2.00
Model time step (min) =	6

Runoff to SCM:

Total runoff (in) =	1.77
Total runoff (ft3) =	444

Runoff to SCM is summarized

SCM Parameters:

Plan area (ft2) =	1000
Sizing factor =	0.333
Design infiltration rate (in/hr) =	0.25
Safety factor =	1
SCM Exfiltration rate (cfs) =	0.0058
Drainage time (hours) =	0
Minimum storage volume (ft3) =	400
Gravel volume (ft3) =	1000
Gravel depth (ft) =	1.0

DMA Summary	Area (ft2)	CN	S	Weighting	Imp. Weighting
New impervious area:	0	98	0.20	1	1
Replaced impervious in USA:	0	98	0.20	0	1
Replaced impervious not USA:	3000	98	0.20	0.5	1
Landscape area:	0	68	4.71	1	0.11
Solid unit pavers set in sand:	0	89	1.24	1	0.58
Non-runoff generating area:	0	N/A	N/A	0	0
Weighted impervious (ft2) =	3000				
Travel path length (ft) =	0.0				
Time of concentration (min) =	5.0	*(rain/runoff)*		*(rain/runoff)*	*(rain/runoff)*
		89%		*10%*	*51%*

				Impervious		Landscape		Solid unit pavers set in sand							
Time (minutes)	Distribution (Type I)	Rainfall Depth (in)	Cumulative Rainfall (in)	Cumulative Runoff Depth (in)	Instantaneous Runoff (in)	Cumulative Runoff Depth (in)	Instantaneous Runoff (in)	Cumulative Runoff Depth (in)	Instantaneous Runoff (in)	Instantaneous Runoff Rate (cfs)	Routed Flow Rate (cfs)	Stormwater Inflow (ft3)	Direct Rain (ft3)	Exfiltration Outflow (ft3)	Bioretention Water Volume (ft3)
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0017	0.0035	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2900	-0.2900	0.0000
12	0.0017	0.0035	0.0070	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2903	-0.2903	0.0000
18	0.0017	0.0035	0.0104	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2903	-0.2903	0.0000

		% inflow that	
runoff %	direct rain vol	is exfiltrated	(max/total vol.)
44%	166.7	100%	30%

SBUH Runoff Calculations

Bioretention Hydraulics

SBUH runoff and routing calculations. Equations are visible to the user

Bioretention hydraulic calculations

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SCS, SBUH Equations Worksheet

- Documents SCS rainfall distribution and hydrologic and hydraulic equations

SCS Type I Distribution (6-min)

Step	Minute	Cummulative Distribution	Incremental Distribution
0	0	0.0000	0.0000
1	6	0.0017	0.0017
2	12	0.0035	0.0017
3	18	0.0052	0.0017
4	24	0.0070	0.0017
5	30	0.0087	0.0017
6	36	0.0105	0.0017
7	42	0.0122	0.0017
8	48	0.0140	0.0017
9	54	0.0157	0.0017
10	60	0.0175	0.0018
11	66	0.0192	0.0018
12	72	0.0210	0.0018
13	78	0.0227	0.0018
14	84	0.0245	0.0018
15	90	0.0262	0.0018
16	96	0.0280	0.0018
17	102	0.0297	0.0018
18	108	0.0315	0.0018
19	114	0.0332	0.0018
20	120	0.0350	0.0018
21	126	0.0368	0.0018
22	132	0.0386	0.0018
23	138	0.0404	0.0018
24	144	0.0423	0.0019
25	150	0.0442	0.0019
26	156	0.0461	0.0019
27	162	0.0480	0.0019
28	168	0.0500	0.0020
29	174	0.0520	0.0020
30	180	0.0541	0.0020

Stormwater Runoff and Routing Equations:

Computing Runoff (SCS and SBUH are the same):

$$R = \frac{(P - I_a)^2}{P - I_a + S}$$

$$I_a = 0.2S$$

$$R = \frac{(P - 0.2S)^2}{P - 0.8S}$$

$$S = \frac{1000}{CN} - 10$$

where:
R = runoff (in)
P = rainfall (in)
Ia = initial abstraction (in)
S = potential maximum soil moisture retention after runoff begins (in)
CN = runoff curve number

SBUH Runoff Routing:

$$I_t = \frac{R_t \times A}{dt} \times \frac{1}{12 \times 60}$$

$$Q_{t+1} = Q_t + w[I_t + I_{t+1} - 2Q_t]$$

$$w = \frac{dt}{(2T_c + dt)}$$

$$T_c = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} \times s^{0.4}}$$

where:
It = instantaneous hydrograph (cfs)
Rt = runoff for current time step (in)
A = contributing area (ft)
dt = calculation time step (min)

Qt = routed stormwater flow
w = routing function
Tc = time of concentration

n = Manning's roughness (0.011 for pavement)
L = flow lenth (ft; computed from tributary area)
P2 = 2-year, 24-hour rainfall (in)
s = 0.005 (ft/ft; assumed value)
Note: set minimum Tc = 5 minutes (Portland BES recommendation)

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Lookups, Constants Worksheet

Lookup Tables for Combo Boxes			Hydraulic Constants		
DMA Type	**Code**		Gravel layer porosity:		0.4
Self-Treating	STA				
Self-Retaining	SRA				
Drains to SCM	2SCM				
Drains to Self-Retaining	2SRA				
SCM Type					
Bioretention					
Direct Infiltration					
DMA Surface Types	**Curve Number**	**Runoff Factor (WQ)**			
Roof	98	0.9			
Concrete or asphalt	98	0.9			
Grouted unit pavers	98	0.9			
Pervious concrete		0.0			
Porous asphalt		0.0			
Unit pavers set in sand	89	0.2			
Open/porous pavers		0.0			
Crushed aggregate		0.0			
Turfblock		0.0			
Landscape	68	0.1			
SCM Optimization					
Area					
Depth					
USA Lookup					
Yes					
No					
Compliance Approach					
WQ Treatment					
Runoff Retention					
Infiltration Rate					
HSG A/B					
HGS C/D					
Site-Specific					

Values include:

- Lists of types/values that populate the combo boxes
- Constants used by SBUH model equations

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