Central Coast Region
Stormwater Control Measure Sizing Calculator

Introduction and Instructions

Version: 2/26/2014

Dubin
Environmental Consulting

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

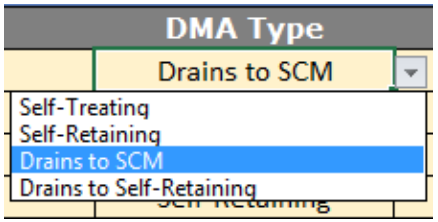
blue = generated results

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:



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 7 slides

Background calculations: Described in the final 3 slides

Project Information Worksheet Overview

Central Coast Region Stormwater Control Measure Sizing Calculator

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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):	
Total new impervious area (ft2):	
Total replaced impervious in a USA (ft2):	
Total replaced impervious not in a USA (ft2):	
Total pervious/landscape area (ft2):	

2. DMA Characterization

Add DMA Row | Remove DMA Row

Name	DMA Type	Area (ft2)	Surface Type	New, Replaced?	Connection
DMA #1	Drains to SCM	5000	Roof	Replaced	SCM #1
DMA #2	Self-Retaining	2500			
DMA #3	Drains to SCM	4000	Landscape	New	

DMA Summary Area

Total project impervious area (ft2):	5000
New impervious area (ft2):	0
Replaced impervious within a USA (ft2):	0
Replaced impervious not in a USA (ft2):	5000
Total pervious/landscape area (ft2):	4000

3. SCM Characterization

Add SCM Row | Remove SCM Row

Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)
SCM #1	Direct Infiltration	2	HSG A/B	0.75	500
SCM #3	Bioretention	1	HSG A/B	0.75	600
SCM #8	Bioretention	1	HSG A/B	0.75	600
SCM #8B	Bioretention	1	HSG A/B	0.75	700

Enter project site location and characteristics using drainage planning documents

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

Define Stormwater Control Measure characteristics. Iteratively test different configurations

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)
SCM #1	455	2.27	2.8
SCM #3	109	0.45	0.0

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	Tributary DMA Area (ft2)	Area Ratio
DMA - SRA #1	4300	DMA #2	2500	0.58

Calculator tracks connections and tributary area ratio for each Self-Retaining Area

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):	
Total new impervious area (ft2):	
Total replaced impervious in a USA (ft2):	
Total replaced impervious not in a USA (ft2):	
Total pervious/landscape area (ft2):	

Enter project name and location

Select: “Tier 2 – Treatment” or “Tier 3 – Retention”

Select design rainfall depth

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

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	Self-Treating	5000			
DMA #3	Drains to SCM	4000	Grouted unit pavers	New	SCM #1
DMA - SRA #1	Self-Retaining	4300			
Building Roof DMA	Drains to Self-Retaining	2000	Roof		DMA - SRA #1

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:

DMA Characteristics Table (Cont.)

- Calculator summarizes DMA impervious and pervious area types

DMA Summary Area	
Total project impervious area (ft2):	5000
New impervious area (ft2):	0
Replaced impervious within a USA (ft2):	0
Replaced impervious not in a USA (ft2):	5000
Total pervious/landscape area (ft2):	4000

Compare the results to the values entered in the “Project Information” table

SCM Characteristics Table

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

3. SCM Characterization			Add SCM Row	Remove SCM Row	
Name	SCM Type	Safety Factor	SCM Soil Type	Infilt. Rate (in/hr)	Area (ft2)
SCM #1	Direct Infiltration	2	HSG A/B	0.75	800
SCM #3	Bioretention	1	HSG A/B	0.75	500
SCM #8	Bioretention	1	HSG A/B	0.75	450
SCM #8B	Bioretention	1	HSG A/B	0.75	600

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

Notes:

- 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 your design

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)
SCM #1	831	2.60	4.3
SCM #3	136	0.68	0.0

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	Tributary DMA Area (ft2)	Tributary / SRA Area Ratio
DMA - SRA #1	4300	Building Roof DMA	2000	0.47

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

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) =	10

DMA Summary	Area (ft2)	CN	S	Weighting
New impervious area:	7000	98	0.20	1
Replaced impervious in USA:	0	98	0.20	0
Replaced impervious not USA:	0	98	0.20	0.5
Landscape area:	0	68	4.71	1
Solid unit pavers set in sand:	0	89	1.24	1
Non-runoff generating area:	4300	N/A	N/A	N/A

Travel path length (ft) =	150.3			
Time of concentration (min) =	5.0	*(rain/runoff)*	*(rain/runoff)*	*(rain/runoff)*
		89%	*10%*	*51%*

SCM Parameters:

Plan area (ft2) =	800
Sizing factor =	0.114
Design infiltration rate (in/hr) =	0.75
Safety factor =	2
SCM Exfiltration rate (cfs) =	0.0139
Drainage time (hours) =	4
Minimum storage volume (ft3) =	831
Gravel volume (ft3) =	2076
Gravel depth (ft) =	2.6

runoff %	*direct rain vol*	*% inflow that is exfiltrated*	*(max/total vol.)*
89%	*133.3*	*100%*	*36%*

SBUH Runoff Calculations

Bioretention Hydraulics

				Impervious		Landscape		Solid unit pavers set in sand				Bioretention Hydraulics			
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
10	0.0027	0.0054	0.0054	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3600	-0.3600	0.0000
20	0.0026	0.0052	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3467	-0.3467	0.0000
30	0.0027	0.0054	0.0160	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3600	-0.3600	0.0000

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

Bioretention hydraulic calculations

SCS, SBUH Equations Worksheet

- Documents SCS rainfall distribution and equations used in hydrologic and hydraulic calculations

SCS Type I Distribution (10-min)

Step	Minute	Cummulative Distribution	Incremental Distribution
0	0	0	0.0000
1	10	0.0027	0.0027
2	20	0.0053	0.0026
3	30	0.008	0.0027
4	40	0.011	0.0030
5	50	0.014	0.0030
6	60	0.017	0.0030
7	70	0.02	0.0030
8	80	0.023	0.0030
9	90	0.026	0.0030
10	100	0.029	0.0030
11	110	0.032	0.0030
12	120	0.035	0.0030
13	130	0.0383	0.0033
14	140	0.0417	0.0034
15	150	0.045	0.0033
16	160	0.0483	0.0033
17	170	0.0517	0.0034
18	180	0.055	0.0033
19	190	0.0583	0.0033
20	200	0.0617	0.0034
21	210	0.065	0.0033
22	220	0.0687	0.0037
23	230	0.0723	0.0036
24	240	0.076	0.0037
25	250	0.0797	0.0037
26	260	0.0833	0.0036
27	270	0.087	0.0037
28	280	0.091	0.0040
29	290	0.095	0.0040
30	300	0.099	0.0040

SCS Type I Distribution (2-min)

Step	Minute	Cummulative Distribution	Incremental Distribution
0	0	0	0.0000
1	2	0.0005	0.0005
2	4	0.0011	0.0006
3	6	0.0016	0.0005
4	8	0.0021	0.0005
5	10	0.0027	0.0006
6	12	0.0032	0.0005
7	14	0.0037	0.0005
8	16	0.0043	0.0006
9	18	0.0048	0.0005
10	20	0.0053	0.0005
11	22	0.0059	0.0006
12	24	0.0064	0.0005
13	26	0.0069	0.0005
14	28	0.0075	0.0006
15	30	0.008	0.0005
16	32	0.0086	0.0006
17	34	0.0092	0.0006
18	36	0.0098	0.0006
19	38	0.0104	0.0006
20	40	0.011	0.0006
21	42	0.0116	0.0006
22	44	0.0122	0.0006
23	46	0.0128	0.0006
24	48	0.0134	0.0006
25	50	0.014	0.0006
26	52	0.0146	0.0006
27	54	0.0152	0.0006
28	56	0.0158	0.0006
29	58	0.0164	0.0006
30	60	0.017	0.0006

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)

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					

- Contains lists of values used by combo boxes and constants used by SBUH model