Documenting Compliance
LID Design and Construction

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County of San Luis Obispo
November 8, 2018
Motivators

**Regulations give you:**
- A mandate
- Client support
- Acceptance of costs
- Structure
- Schedule
- Accountability

**Supply your own:**
- Enthusiasm
- Interest
- Energy

**To achieve:**
- Synergies
- Opportunities
- Elegance
Why Use Low Impact Development?
Conventional Urban Drainage

- Impervious surfaces: roofs and pavement
- Catch basins and piped drainage
- “Collect and convey” design objective
### Watershed and Stream Scale

<table>
<thead>
<tr>
<th>Impact</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding and scouring of stream beds</td>
<td>Higher peak flows, flooding, and scouring of stream beds</td>
</tr>
<tr>
<td>Flash flows</td>
<td>Lower time of concentration, flash flows</td>
</tr>
<tr>
<td>Discharge when runoff did not previously occur</td>
<td>Runoff from small storms, discharge when runoff did not previously occur</td>
</tr>
<tr>
<td>Stream erosion at moderate stream flows</td>
<td>Increased runoff durations, stream erosion at moderate stream flows</td>
</tr>
<tr>
<td>Higher pollutant loading</td>
<td>Greater runoff volumes, higher pollutant loading</td>
</tr>
<tr>
<td>Conveys trash and gross pollutants</td>
<td>Greater runoff energy, conveys trash and gross pollutants</td>
</tr>
<tr>
<td>Lower and less frequent stream base flow</td>
<td>Decreased infiltration, lower and less frequent stream base flow</td>
</tr>
<tr>
<td>High pollutant concentrations</td>
<td>Dry weather discharges, high pollutant concentrations</td>
</tr>
</tbody>
</table>
## LID Design Objectives

<table>
<thead>
<tr>
<th>Watershed and Stream Scale</th>
<th>Site scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce peak flows</td>
<td>Detain runoff on site</td>
</tr>
<tr>
<td>Increase time of concentration</td>
<td>Slow runoff from leaving site</td>
</tr>
<tr>
<td>No runoff from small storms</td>
<td>Infiltrate, evapotranspirate and reuse</td>
</tr>
<tr>
<td>Reduce duration of moderate flows</td>
<td>Let runoff seep away very slowly</td>
</tr>
<tr>
<td>Reduce runoff volume</td>
<td>Infiltrate and reuse where possible</td>
</tr>
<tr>
<td>Reduce runoff energy</td>
<td>Detain and slow flows</td>
</tr>
<tr>
<td>Increase groundwater storage and stream base flows</td>
<td>Facilitate infiltration</td>
</tr>
<tr>
<td>Reduce pollutants in runoff</td>
<td>Detain and filter runoff</td>
</tr>
<tr>
<td>Protect against spills and dumping</td>
<td>Disconnect drainage and filter runoff</td>
</tr>
</tbody>
</table>
LID Drainage Design

- Minimize roofs and paving
- Substitute pervious paving where possible
- Disperse runoff to landscaping
- Direct runoff to bioretention facilities
Bioretention Advantages

• Filtration and pollutant sequestration
• Biological processing and renewal
• No mosquito problems
• Mimic natural hydrology
• Attractive landscape amenity
• Potential use as park or playground
• Low maintenance
• Easy to inspect
Pollutant Fate and Transport
Resilience
Resilience
Designing the Site for LID
Where the Rubber Meets the River
Development Process

Pre-Application Meeting → Completed Application → “Deemed Complete”

Planning Commission

Condition of Approval

CEQA Review

Section Review

Detailed Design

Plan Set and Permit Application

Construction
Applications for development approvals must incorporate Low Impact Development drainage design, and must be in accordance with the requirements and criteria in the Guidebook.

For purposes of preliminary planning, these requirements and criteria include the following:

- Disperse runoff from impervious roofs and pavement to adjacent pervious areas where feasible.
- Include bioretention facilities to detain, retain, and treat runoff from remaining roofs and pavement.
- Put bioretention facilities in high-visibility, well-trafficked, common accessible areas and integrate them with site landscaping.
### Placing bioretention on the site

- High-visibility, well-trafficked places
- Common, accessible areas
- Dispersed throughout the site
- Drain only impervious roofs and pavement
- Use surface drainage; keep runs short
- Make facilities flat and level
- Make top of soil elevation high as possible
- Follow the design criteria
Best Planning for Parking Lots
Commercial Project
Gas Station
Best Planning for Subdivisions

- Direct a portion of roof runoff to yard
- Direct remaining runoff to street
- Drain street to a commonly owned bioretention facility
- About 1 facility for each 6-10 lots
Subdivisions

- Drain a portion of each roof to yard
- Drain driveways to street
- Drain street to bioretention facilities on commonly owned parcels
Avoid design conflicts

- Elevations consistent with grading and architectural plans
- Facilities do not interfere with parking or pedestrian circulation
- Protection of adjacent paving and structures has been considered
- Utilities are located elsewhere
Documenting that Your LID Design Achieves Compliance
Documenting LID Site Design

Paved or Roofed Area
LID Site Design Principles
LID Site Design Principles

- Mimic natural hydrology
- Disperse runoff
- Keep drainage areas small
- Don’t concentrate runoff
- Don’t allow run-on from landscaped or natural areas
Drainage Management Areas
Drainage Management Areas

DMA 1
DMA 2
DMA 3
DMA 4
Drainage Management Areas

DMA 4
DMA 1
DMA 3
DMA 2
Drainage Management Areas

Natural

DMA-1
DMA-2
DMA-3
DMA-4

DMA-8

DMA-5
Paved

DMA-6

DMA-7

Landscaped

Landscaped
Drainage Management Areas

Natural

Possible Bioretention Locations

DMA 1
DMA 2
DMA 3
DMA 4
Options – Pervious DMAs

- DMA-8
  - Self-treating?
  - Self-retaining?
  - Drain to Facility?
• Self-Treating
  - Drain directly to storm drain system

• Self-Retaining
  - Grade concave to average one-inch depth

• Drain to Facility
  - Use runoff factor to account for contribution
Self-Treating and Self-Retaining

- Essential to LID design
- Track and quantify runoff reduction

Steps:
- Delineate Drainage Management Areas
- Classify DMAs
  1. Self-treating areas
  2. Self-retaining areas
  3. Areas draining to self-retaining areas
  4. Areas that drain to IMPs
Self-treating Areas
Self-retaining Areas
Areas draining to self-retaining
Options – Combining DMAs

Option to combine DMAs if they have identical runoff factors (for example, roofs and paving) and drainage is routed to the same location.
Tabulate DMAs

### Table

<table>
<thead>
<tr>
<th>DMA</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1300</td>
</tr>
<tr>
<td>2</td>
<td>1050</td>
</tr>
<tr>
<td>3</td>
<td>1300</td>
</tr>
<tr>
<td>4</td>
<td>1050</td>
</tr>
<tr>
<td>5</td>
<td>4000</td>
</tr>
<tr>
<td>6</td>
<td>5570</td>
</tr>
<tr>
<td>7</td>
<td>7025</td>
</tr>
<tr>
<td>8</td>
<td>9350</td>
</tr>
<tr>
<td>Total</td>
<td>30645</td>
</tr>
</tbody>
</table>
Select and Lay Out Facilities

<table>
<thead>
<tr>
<th>DMA</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1300</td>
</tr>
<tr>
<td>2</td>
<td>1050</td>
</tr>
<tr>
<td>3</td>
<td>1300</td>
</tr>
<tr>
<td>4</td>
<td>1050</td>
</tr>
<tr>
<td>5</td>
<td>4000</td>
</tr>
<tr>
<td>6</td>
<td>5570</td>
</tr>
<tr>
<td>7</td>
<td>7025</td>
</tr>
<tr>
<td>8</td>
<td>9350</td>
</tr>
<tr>
<td>Total</td>
<td>30645</td>
</tr>
</tbody>
</table>
Using the Updated Central Coast SCM Sizing Calculator
1. Calculator implements *routing method* allowed in the PCRs

2. Calculates bioretention dimensions for Tier 2 and Tier 3 projects
   – Uses SBUH model to compute minimum SCM dimensions

3. Functions as interactive design aid to improve drainage and bioretention configuration
Features and Notes

- MS Excel workbook with VBA code to guide data entry and hydraulic calculations
  - Allow “Macros” when opening

- Worksheets are protected
  - prevent changes in format, row and column locations, etc.
  - protect embedded equations

- Combo box/drop down lists are used wherever possible to guide data entry values:
  - yellow = data entry
  - blue = generated results
  - grayed-out = not used
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
### Project Information Worksheet

#### Central Coast Region
Stormwater Control Measure Sizing Calculator

**Version:** 11/18/2014

### 1. Project Information
- **Project name:** Working test
- **Project location:** Working test
- **Tier:** Tier 2/Tier 3/Tier 4
- **Design rainfall depth (in):** 2.4

<table>
<thead>
<tr>
<th>Total project area (ft²):</th>
<th>14000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total new impervious area (ft²):</td>
<td>10000</td>
</tr>
<tr>
<td>Total replaced impervious in a USA (ft²):</td>
<td>0</td>
</tr>
<tr>
<td>Total replaced impervious not in a USA (ft²):</td>
<td>0</td>
</tr>
<tr>
<td>Total pervious/landscape area (ft²):</td>
<td>0</td>
</tr>
</tbody>
</table>

### 2. DMA Characterization
- DMA #2: Drains to SCM, 10000 ft², Roof, New, SCM #2
- DMA #7: Self-Treating, 4000 ft², Surface, New, SCM #1

**DMA Summary Area**
- **Total project impervious area (ft²):** 20000
- **New impervious area (ft²):** 10000
- **Replaced impervious within a USA (ft²):** 0
- **Replaced impervious not in a USA (ft²):** 10000
- **Total pervious/landscape area (ft²):** 0

### 3. SCM Characterization
- **SCM #1:** Bioretention, 1, HSG C/D, 0.25 in/hr, 700 ft², Yes, 8 in
- **SCM #2:** Direct Infiltration, 2, HSG C/D, 0.25 in/hr, 700 ft²

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Enter project site location and characteristics using drainage planning documents

Define Drainage Management Areas. Add/remove and modify characteristics

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

### 4. Run SBUH Model

| Launch Model |

### 5. SCM Minimum Sizing Requirements

<table>
<thead>
<tr>
<th>SCM Name</th>
<th>Min. Required Storage Vol. (ft³)</th>
<th>Depth Below Underdrain (ft)</th>
<th>Drain Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM #1</td>
<td>455</td>
<td>2.27</td>
<td>2.8</td>
</tr>
<tr>
<td>SCM #3</td>
<td>109</td>
<td>0.45</td>
<td>0.0</td>
</tr>
</tbody>
</table>

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

### 6. Self-Retaining Area Sizing Checks

<table>
<thead>
<tr>
<th>Self-Retaining DMA Name</th>
<th>Self-Retaining DMA Area (ft²)</th>
<th>Tributary DMA Name</th>
<th>Tributary DMA Area (ft²)</th>
<th>Area Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA - SRA #1</td>
<td>4300</td>
<td>DMA #2</td>
<td>2500</td>
<td>0.58</td>
</tr>
</tbody>
</table>

Calculator tracks connections and tributary area ratio for each Self-Retaining Area
## DMA Characteristics Table

### DMA Characterization Table

<table>
<thead>
<tr>
<th>Name</th>
<th>DMA Type</th>
<th>Area (ft²)</th>
<th>Surface Type</th>
<th>New, Replaced?</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA #1</td>
<td>Self-Treating</td>
<td>5000</td>
<td>Grouted unit pavers</td>
<td></td>
<td>SCM #1</td>
</tr>
<tr>
<td>DMA #3</td>
<td>Drains to SCM</td>
<td>4000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA - SRA #1</td>
<td>Self-Retaining</td>
<td>4300</td>
<td></td>
<td>New</td>
<td>Scour #1</td>
</tr>
<tr>
<td>Building Roof DMA</td>
<td>Drains to Self-Retaining</td>
<td>2000</td>
<td>Roof</td>
<td></td>
<td>Building Roof DMA</td>
</tr>
</tbody>
</table>

- **Provide descriptive name**
- **Select DMA Area**
  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
- **Select DMA connection for “Drains to SCM” and “Drains to Self-Retaining” DMA types:**
  - New
  - Replaced
  - Replaced in an Urban Sustainability Area
- **For impervious areas, select:**
  1. New
  2. Replaced

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

[Add DMA Row] [Remove DMA Row]
## SCM Characteristics Table

<table>
<thead>
<tr>
<th>Name</th>
<th>SCM Type</th>
<th>Safety Factor</th>
<th>SCM Soil Type</th>
<th>Infiltr. Rate (in/hr)</th>
<th>Area (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM #1</td>
<td>Direct Infiltration</td>
<td>2</td>
<td>HSG A/B</td>
<td>0.75</td>
<td>800</td>
</tr>
<tr>
<td>SCM #3</td>
<td>Bioretention</td>
<td>1</td>
<td>HSG A/B</td>
<td>0.75</td>
<td>500</td>
</tr>
<tr>
<td>SCM #8</td>
<td>Bioretention</td>
<td>1</td>
<td>HSG A/B</td>
<td>0.75</td>
<td>450</td>
</tr>
<tr>
<td>SCM #8B</td>
<td>Bioretention</td>
<td>1</td>
<td>HSG A/B</td>
<td>0.75</td>
<td>600</td>
</tr>
</tbody>
</table>

### 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.

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

<table>
<thead>
<tr>
<th>Flow Control</th>
<th>Reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orifice?</td>
<td>Depth (in)</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>6</td>
</tr>
</tbody>
</table>

**NEW**

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
Launching Model and Viewing Results

### 4. Run SBUH Model

- **Launch Model**

### 5. SCM Minimum Sizing Requirements

<table>
<thead>
<tr>
<th>SCM Name</th>
<th>Min. Required Storage Vol. (ft³)</th>
<th>Depth Below Underdrain (ft)</th>
<th>Drain Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM #1</td>
<td>831</td>
<td>2.60</td>
<td>4.3</td>
</tr>
<tr>
<td>SCM #3</td>
<td>136</td>
<td>0.68</td>
<td>0.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Self-Retaining DMA Name</th>
<th>Self-Retaining DMA Area (ft²)</th>
<th>Tributary DMA Name</th>
<th>Tributary DMA Area (ft²)</th>
<th>Tributary / SRA Area Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA - SRA #1</td>
<td>4300</td>
<td>Building Roof DMA</td>
<td>2000</td>
<td>0.47</td>
</tr>
</tbody>
</table>

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

### SCM #1

<table>
<thead>
<tr>
<th>SBUH Parameter</th>
<th>Value</th>
<th>SCM Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design rainfall depth (in)</td>
<td>2.00</td>
<td>Plan area (ft²)</td>
</tr>
<tr>
<td>Model time step (min)</td>
<td>10</td>
<td>Sizing factor</td>
</tr>
</tbody>
</table>

### DMA Summary

<table>
<thead>
<tr>
<th>New impervious area</th>
<th>7000</th>
<th>Design infiltration rate (in/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN</td>
<td>98</td>
<td>0.20</td>
</tr>
</tbody>
</table>

### Bioretention Hydraulic Calculations

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Impervious</th>
<th>Landscape</th>
<th>Solid unit pavers set in sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>10</td>
<td>0.0027</td>
<td>0.0054</td>
<td>0.0054</td>
</tr>
<tr>
<td>20</td>
<td>0.0052</td>
<td>0.0106</td>
<td>0.0106</td>
</tr>
<tr>
<td>30</td>
<td>0.0054</td>
<td>0.0160</td>
<td>0.0160</td>
</tr>
</tbody>
</table>

### Notes
- Yellow-shaded cells are copied from “Project Information” sheet.
- Blue-shaded cells contain results that are copied to the “Project Information” sheet.
- SBUH runoff and routing calculations. Equations are visible to the user.
- Bioretention hydraulic calculations.
Whispering Pines Lane Example

- Using Calculator as design aid
- Testing design iterations
Subdivisions

• Drain a portion of each roof to yard
• Drain driveways to street
• Drain street to bioretention facilities on commonly owned parcels
Detailed DMA Setup

- Describing DMAs
  - Go to the level of detail that can affect SCM design
    - Different surface types
    - Different control approach
Detailed DMA Setup

• Each DMA gets a line in the *DMA Characterization* table

<table>
<thead>
<tr>
<th>Name</th>
<th>DMA Type</th>
<th>Area (ft²)</th>
<th>Surface Type</th>
<th>New, Replaced?</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-RF</td>
<td>Drains to SCM</td>
<td>1846</td>
<td>Roof</td>
<td>New</td>
<td>Bioretention-1</td>
</tr>
<tr>
<td>1-RR</td>
<td>Drains to Self-Retaining</td>
<td>1388</td>
<td>Roof</td>
<td></td>
<td>1-RY</td>
</tr>
<tr>
<td>1-DW</td>
<td>Drains to SCM</td>
<td>805</td>
<td>Concrete or asphalt</td>
<td>New</td>
<td>Bioretention-1</td>
</tr>
<tr>
<td>1-FY-1</td>
<td>Self-Retaining</td>
<td>780</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-FY-2</td>
<td>Self-Retaining</td>
<td>1625</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-RY</td>
<td>Self-Retaining</td>
<td>4910</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### All DMAs Defined

#### 2. DMA Characterization

<table>
<thead>
<tr>
<th>Name</th>
<th>DMA Type</th>
<th>Area (ft²)</th>
<th>Surface Type</th>
<th>New, Replaced?</th>
<th>Connection</th>
</tr>
</thead>
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<td>1388</td>
<td>Roof</td>
<td></td>
<td>1-RY</td>
</tr>
<tr>
<td>1-DW</td>
<td>Drains to SCM</td>
<td>805</td>
<td>Concrete or asphalt</td>
<td>New</td>
<td>Bioretention-1</td>
</tr>
<tr>
<td>1-FY-1</td>
<td>Self-Retaining</td>
<td>780</td>
<td>Roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-RY</td>
<td>Self-Retaining</td>
<td>4910</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-RF</td>
<td>Drains to SCM</td>
<td>2204</td>
<td>Roof</td>
<td>New</td>
<td>Bioretention-1</td>
</tr>
<tr>
<td>2-RR</td>
<td>Drains to Self-Retaining</td>
<td>2350</td>
<td>Roof</td>
<td></td>
<td>2-RY</td>
</tr>
<tr>
<td>2-DW</td>
<td>Drains to SCM</td>
<td>400</td>
<td>Concrete or asphalt</td>
<td>New</td>
<td>Bioretention-1</td>
</tr>
<tr>
<td>2-FY-1</td>
<td>Self-Retaining</td>
<td>1620</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-FY-2</td>
<td>Self-Retaining</td>
<td>370</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-RY</td>
<td>Self-Retaining</td>
<td>3580</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-RF</td>
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</table>
SCM Setup

- Project reserves two bioretention areas
  - 2600 and 2700 ft²
- Site grading must promote drainage into these areas
Detailed SCM Setup

- Define SCM configuration
  - SCM name, type
  - Soil, SCM area
  - Flow control orifice?

### 3. SCM Characterization

<table>
<thead>
<tr>
<th>Name</th>
<th>SCM Type</th>
<th>Safety Factor</th>
<th>SCM Soil Type</th>
<th>Infiltr. Rate (in/hr)</th>
<th>Area (ft²)</th>
<th>Flow Control</th>
<th>Reservoir</th>
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</thead>
<tbody>
<tr>
<td>Bioretention-1</td>
<td>Bioretention</td>
<td>1</td>
<td>HSG C/D</td>
<td>0.25</td>
<td>2600</td>
<td>No</td>
<td>Depth (in)</td>
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<td>Bioretention-2</td>
<td>Bioretention</td>
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<td>HSG C/D</td>
<td>0.25</td>
<td>2700</td>
<td>No</td>
<td>Depth (in)</td>
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</table>
• Check self-retaining area ratios (<2:1)
• Calculate min. SCM storage volume
<table>
<thead>
<tr>
<th>Calculator as Design Aid</th>
</tr>
</thead>
</table>

- After initial SCM sizing, iterate on stormwater design options:
  - Reduce impervious areas
  - Modify surface types to reduce runoff and/or integrate runoff management into landscape (drain to self-retaining areas)
  - Configure bioretention with flow control orifice and deeper surface reservoir
Surface Type Options

- Look for options to reduce runoff
- Drainage ideas?
  1. Route 1-RF to backyard self-retaining area
  2. Driveway as unit pavers in sand
  3. Driveway drains to 1-FY-2
## Effect of Surface Type

<table>
<thead>
<tr>
<th>Option</th>
<th>Effect</th>
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<tbody>
<tr>
<td>Route 1-RF to backyard self-retaining area</td>
<td>1846 ft² removed from bioretention drainage area</td>
</tr>
<tr>
<td>Driveway as unit pavers in sand</td>
<td>Runoff factor reduced from 1.0 to 0.2</td>
</tr>
<tr>
<td>Driveway drains to 1-FY-2</td>
<td>805 ft² removed from bioretention drainage area</td>
</tr>
</tbody>
</table>

- Consider other drainage design concerns
  - soggy yards, driveway elevation, etc.
Adding a Flow Control Orifice

- Holds water in SCM longer and allows for more infiltration → smaller volume
- Gravel volumes reduced typically 20+% percent
- Engineers balance design complexity with potential space/cost savings
Flow Orifice Example

- 10,000 ft² impervious tributary area
- SCMs with and without flow control orifice

### 3. SCM Characterization

<table>
<thead>
<tr>
<th>SCM Name</th>
<th>SCM Type</th>
<th>Safety Factor</th>
<th>SCM Soil Type</th>
<th>Infiltration Rate (in/hr)</th>
<th>Area (ft²)</th>
<th>Orifice?</th>
<th>Reservoir Depth (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM-1</td>
<td>Bioretention</td>
<td>1</td>
<td>HSG C/D</td>
<td>0.25</td>
<td>800</td>
<td>No</td>
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<tr>
<td>SCM-2</td>
<td>Bioretention</td>
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<td>HSG C/D</td>
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<td>800</td>
<td>Yes</td>
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### 4. Run SBUH Model

- Launch Model

### 5. SCM Minimum Sizing Requirements

<table>
<thead>
<tr>
<th>SCM Name</th>
<th>Min. Required Storage Vol. (ft³)</th>
<th>Depth Below Underdrain (ft)</th>
<th>Drain Time (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCM-1</td>
<td>1487</td>
<td>4.65</td>
<td>74.3</td>
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<tr>
<td>SCM-2</td>
<td>987</td>
<td>3.08</td>
<td>49.3</td>
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</table>
Bioretention Design and Construction

Dan Cloak
Don’t create pits
Don’t create pits
Problems with pits
Make This Happen

- Bioretention facilities are level so they “fill up like a bathtub.”
Not this

Or this
Bioretention Design Criteria
Flat, Flat, Flat
Flat, Flat, Flat
Flat, Flat, Flat
Foundations and Pavement
Foundations and Pavement
Geotechnically Difficult Sites
No Storm Drain
Call out elevations

- **Outlet structure**
  - Top of overflow grate
  - Underdrain connection

- **Inlet**
  - Flow line at inlet
  - Top of curb
  - Top of adjacent paving

- **Soil layers**
  - Top of soil layer
  - Bottom of gravel layer
  - Bottom of soil layer
Gravel and Underdrain

- **Class 2 permeable**
  - Caltrans spec 68-2.02(F)(3)
- **No filter fabric**
- **Underdrain**
  - Discharge elevation at top of gravel layer
  - PVC SDR 35 or equivalent; holes facing down
  - Solid pipe for 2' closest to outlet structure
  - Cleanout
Planting Medium

- 60-70% **Washed** Sand
  - ASTM C33 for fine aggregate
- 30-40% Compost
  - Certified through US Composting Council Seal of Testing Assurance Program
- Install in 8"-12" lifts
- Do not compact
- Do not overfill
- Leave room for mulch
Planting

• Select plants for fast-draining soils
• Select for facility location
• Avoid problem conditions
  – Overly dense plantings
  – Aggressive roots
  – Invasive weeds
  – Need for a lot of irrigation or for fertilization
Irrigation

- Separate Zone for Bioretention
- Drip Irrigation
- Smart Controllers
Construction

- Layout
- Excavation
- Overflow or Surface Connection
- Underground connection (underdrain)
- Drain rock/subdrain
- Soil Mix
- Irrigation
- Planting
- Final
Construction Inspection

- Yes, inspections are needed
- Special inspections (or inspectors) may be appropriate
- Edit construction checklist and deliver to general contractor at pre-construction meeting
- Make sure landscape contractor gets the message(s)
  - Elevations
  - Additions of material
  - Fertilizers
2-Year Warranty Recommended

- Extension of standard 1-year warranty for landscaping
- Allows identification and correction of problems during rainy season
Key O&M Requirements

- Composted mulch
- No fertilizer
  - See instructions for using compost tea
- Weed manually
  - Listed “natural” herbicides for invasions
- No synthetic pesticides
  - Beneficial nematodes or listed natural pesticides
Typical maintenance plan

- Inspect weekly for trash and remove
- Weed monthly
- Check drainage and inspect facilities before the rainy season
- Inspect after each significant rainfall
- Annual vegetation cut-back and maintenance