Requirements for Land Development Projects

Using the Updated Stormwater Technical Guide and Calculator

Cathleen Garnand
Dan Cloak
Tony Dubin

November 2015
Welcome

Cathleen Garnand
What’s New

Dan Cloak
What’s the Same (not new)

- Low Impact Development
- Delineate Drainage Management Areas
- Use the *Guide*, Calculator, and Templates to prepare your Stormwater Control Plan
<table>
<thead>
<tr>
<th>What’s New—Technical Stuff</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduce required storage volumes by incorporating an orifice on underdrain</td>
</tr>
<tr>
<td>• Instructions on designing bioretention with downstream basin storage</td>
</tr>
</tbody>
</table>
New: Specify up to 18" average depth in reservoir

Typical Cross Section

V_{SURFACE}

24"

Sand/Co

Gravel

V_{SUBSURFACE}

Orifice

SD
What’s New—Guidance

• Template for a Stormwater Facilities Operation and Maintenance Plan

• Example submittals:
  – Stormwater Control Plan for a Commercial Project
  – Stormwater Control Plan for a Residential Subdivision
  – Draft Stormwater Facilities Operation and Maintenance Plan for a Commercial Project
  – Draft Stormwater Facilities Operation and Maintenance Plan for a Residential Subdivision
About the Post-Construction Requirements

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PCRs Overview

- History
- Thresholds and Standards
- Development Review Process
PCRs History

1987 Congress adds Section 402(p) to Clean Water Act

1990 USEPA regulations require states to issue stormwater NPDES permits to large municipalities

1990 Regional Water Boards issue first Phase I stormwater NPDES permits

1999 USEPA Phase II Regulations require states to issue stormwater permits to small municipalities
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>State Water Resources Control Board “Bellflower decision” confirms municipalities must require new developments to treat runoff</td>
</tr>
<tr>
<td>2000</td>
<td>“Hydrograph Modification Management” first appears in draft stormwater NPDES permit language in SF Bay Area</td>
</tr>
<tr>
<td>2003</td>
<td>California issues first Phase II permit to smaller municipalities</td>
</tr>
<tr>
<td>2006</td>
<td>First Hydrograph Modification Management Plans go into effect</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
</tr>
<tr>
<td>------</td>
<td>-------</td>
</tr>
<tr>
<td>2008</td>
<td>Region 3 issues “enrollment strategy” letter</td>
</tr>
<tr>
<td>2009</td>
<td>Joint Effort Initiated</td>
</tr>
<tr>
<td>2012</td>
<td>Region 3 adopts PCRs</td>
</tr>
<tr>
<td>2013</td>
<td>Phase II permit reissued; Provision E.12 requires treatment and baseline hydromodification management for all projects ( \geq 5000 \text{ SF impervious area} )</td>
</tr>
<tr>
<td>2013</td>
<td>Region 3 adopts PCRs superseding Provision E.12</td>
</tr>
<tr>
<td>2014</td>
<td>PCRs in effect March 6, 2014</td>
</tr>
</tbody>
</table>
PCRs Implementation

- County of Santa Barbara obtained a State Water Resources Control Board grant to assist with PCRs implementation
- *Guide* facilitates compliance
  - Applicants ↔ Reviewers communication
  - Integrating design with development process
## Thresholds and Requirements

<table>
<thead>
<tr>
<th>Tier</th>
<th>Threshold</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>≥ 2,500 SF</td>
<td>Minimize runoff</td>
</tr>
<tr>
<td>2</td>
<td>≥ 5,000 SF net</td>
<td>Treat runoff</td>
</tr>
<tr>
<td>3</td>
<td>≥ 15,000 SF</td>
<td>Retain runoff</td>
</tr>
<tr>
<td>4</td>
<td>≥ 22,500 SF</td>
<td>Control peak runoff</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pre-Project</th>
<th>Post-Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000 SF</td>
<td>7,000 SF</td>
</tr>
<tr>
<td></td>
<td>3,000 SF</td>
</tr>
<tr>
<td>Question</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Does repaving or re-roofing count?</td>
<td></td>
</tr>
<tr>
<td>Does pervious pavement count?</td>
<td></td>
</tr>
<tr>
<td>Are swimming pools impervious?</td>
<td></td>
</tr>
<tr>
<td>Is gravel impervious?</td>
<td></td>
</tr>
<tr>
<td>Are public improvements included?</td>
<td></td>
</tr>
</tbody>
</table>
Principles of Low Impact Development

Dan Cloak
Conventional Urban Drainage

- Impervious surfaces: roofs and pavement
- Catch basins and piped drainage
- “Collect and convey” design objective
### Drainage Impacts

#### 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>Bankfull Stage and increased stream energy convey trash and gross pollutants</td>
</tr>
<tr>
<td>Flash flows</td>
<td>Discharge when runoff did not previously occur</td>
</tr>
<tr>
<td>Lower and less frequent stream base flow</td>
<td>Dry weather discharges with high pollutant concentrations</td>
</tr>
<tr>
<td>Stream erosion at moderate stream flow rates</td>
<td>Greater runoff energy</td>
</tr>
<tr>
<td>Higher pollutant loading</td>
<td>Greater runoff volumes and energy</td>
</tr>
<tr>
<td>Conveys trash and gross pollutants</td>
<td>Decreased infiltration</td>
</tr>
</tbody>
</table>

![Diagram of stream dimensions: bankfull stage and width](image)
# 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, evapotranspire 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>
• Minimize imperviousness
  – 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
Bioretention & Urban Landscape
Resilience
Resilience
Resilience
Using the Stormwater Technical Guide

Dan Cloak
Stormwater Control Plan

• A Report and an Exhibit

• Four ways to follow
  – Step-by-Step instructions
  – Checklist (p. 3-2)
  – Template (available, to be updated)
  – Examples (in review, to be posted soon)

• Make the first draft complete and thorough
Using the SCP Template

- **Not** for “filling in the blanks”
  - Follow the manual
- Assists communication between the preparer and the reviewer
- Organizes information in a consistent way
- **Do** include concise, explanatory narratives
- **Don’t** add extraneous information
  - Reports prepared for other purposes
  - Copies of readily available information
Steps in Preparing an SCP

1. Project Data
2. Opportunities and Constraints
3. Conceptual Site Design
4. Calculations and Documentation
5. Design Details
6. Source Controls
7. Stormwater Facility Maintenance
8. Construction Cross-Checklist
9. Certification
1. Project Data

- Project Name/Number
- Application Submittal Date
- Location
- Phase
- Project Type/Description
- Total Site Area
1. Project Data

A. New Impervious Area
B. Replaced Impervious Area
C. Pre-Project Impervious Area
D. Post-Project Impervious Area

Net Impervious Area = A + B - (C - D)
1. Project Data

- Watershed Management Zone
- Design Storm Frequency and Depth
- Urban Sustainability Area
2. Opportunities and Constraints

- Topography
- Unbuildable Areas
  - Setbacks from street or adjacent lots
  - Setbacks from watercourses
  - Odd-shaped areas
- Factors that facilitate or prevent infiltration
3. Conceptual Site Design

- Analyze Project for LID
- Develop and Document LID Drainage Design
- Specify LID Preliminary Design Details

Coordinate with Site Design and Landscape Design
Steps/priorities:

• Optimize the site layout
• Use pervious surfaces
• Direct drainage to landscaped areas
• Drain to bioretention or other facilities to retain, treat, and control flows
Optimize the Site Layout

• Define the development envelope
• Minimize grading
• Set back from creeks, wetlands, and riparian areas
• Preserve significant trees
Optimize the Site Layout

- Limit paving and roofs
- Preserve and use permeable soils
- Detain and retain runoff throughout the site
- Use drainage as a design element
Use Pervious Surfaces

- Permeable pavements
- Green roofs
Disperse Runoff
Harvesting and Use
Bioretention

- Infiltration
- Evapotranspiration
- Discharge (biotreatment)
- Losses

3-5
6. Source Controls

- Identify sources from checklist in Appendix A
- Complete table in format of Table 3-1
- Narrative to explain special features, materials, or methods of construction

<table>
<thead>
<tr>
<th>Potential Source of Runoff Pollutants</th>
<th>Permanent/Structural Source Control BMPs</th>
<th>Operational/Pollution Prevention BMPs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
### Common Sources

- Pools, spas, ponds, fountains
- Food service
- Refuse areas
- Materials storage
- Vehicle cleaning and maintenance
- Fueling areas
- Loading docks
- Condensate drains; drainage sumps
7. Treatment Facility Maintenance

- Include a general description of facility maintenance requirements
- Describe the means by which maintenance will be financed and implemented
- Municipality may require execution of an agreement or statement that applicant will do so
- Include a statement accepting responsibility for interim maintenance following construction
8. Construction Cross-Checklist

<table>
<thead>
<tr>
<th>Stormwater Control Plan Page #</th>
<th>BMP Description</th>
<th>See Plan Sheet #s</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
Certification

- “The selection, size, and preliminary design of treatment and retention control measures in this plan are in accordance with the current edition of the Santa Barbara County Project Clean Water’s Stormwater Technical Guide.”
Documenting LID Site Design

Dan Cloak
Step-by-Step

1. Delineate entire site into Drainage Management Areas (DMAs).
2. Categorize and tabulate DMAs. Minimize impervious area and disperse runoff.
3. Select and lay out LID facilities.
4. Use the sizing calculator to evaluate facility footprints.
5. Iterate until all facilities meet or exceed the minimum required area.
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
Drainage Management Areas

Possible Bioretention Locations

DMA 1
DMA 2
DMA 3
DMA 4

Natural
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

Use a curb to avoid run-on from self-treating areas

Grade self-retaining areas to drain inward.

Consider that adjacent roofs or paved areas could drain to self-retaining areas (not to exceed 2:1)
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.
Roof ridges and grade breaks
Roof and Grading Plans
2. Tabulate DMAs

<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><strong>Total</strong></td>
<td><strong>30645</strong></td>
</tr>
</tbody>
</table>
3. Select and Lay Out Facilities

**DMA SF**

<table>
<thead>
<tr>
<th>DMA</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
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<tr>
<td>3</td>
<td>1300</td>
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<tr>
<td>4</td>
<td>1050</td>
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<tr>
<td>5</td>
<td>4000</td>
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<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><strong>Total</strong></td>
<td><strong>30645</strong></td>
</tr>
</tbody>
</table>

**Legend:**
- DMA-1: 1300 SF
- DMA-2: 1050 SF
- DMA-3: 1300 SF
- DMA-4: 1050 SF
- DMA-5: 4000 SF
- DMA-6: 5570 SF
- DMA-7: 7025 SF
- DMA-8: 9350 SF
- Total: 30645 SF
Best Planning for Parking Lots
Commercial Project

[Diagram showing a commercial project site with various sections labeled, including DMA-1 (Paving and Roof), DMA-2 (Paving), DMA-3 (Paving, Walkway, and Plaza), DMA-4 (Landscape), DMA-5 (Landscape), DMA-6 (Landscape), Bioretention Facility #1, Bioretention Facility #2, and Bioretention Facility #3.]

6" Sand/compost mix

18" Class 2 permeable

As req'd
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
Break
Bioretention Design and Construction

Dan Cloak
Don’t create pits
• Bioretention facilities are level so they “fill up like a bathtub.”
Flat, Flat, Flat
Flat, Flat, Flat
Foundations and Pavement
Foundations and Pavement
Foundations and Pavement

Figure 4-4. Bioretention Facility Cross-Section
Not to Scale

- Curb cut (or curb inlet if needed to ensure runoff capture)
- Overflow structure: Concrete drop inlet or manhole with frame. Atrium or bee hive grate preferred, ¼” openings.
- Walls as needed to establish constant rim elevation around perimeter of facility.
- Underdrain discharge at TOL elevation
- Water spreader and mulch (if specified in landscape plans)
- Schedule 80 (no perforations) seal penetration with grout
- 3” max. mulch if specified in landscape plans
- Underdrain discharge at TOL elevation
- Thread/cap underdrain (orifice option)
- To storm drain or approved discharge point

Notes:
- No liner, no filter fabric, no landscape cloth.
- Maintain BGL, TOL, TSL throughout facility area at elevations to be specified in plan.
- Class 2 permeable material layer may extend below and underneath drop inlet.
- Elevation of underdrain discharge is at top of gravel layer.
- See Chapter 4 for instructions on facility sizing and additional specifications.
- Drawings available at www.centralcoastldr.org can be adapted and customized to meet project requirements and these minimum specifications.
Geotechnically Difficult Sites
High Groundwater

Diagram showing the flow of groundwater with arrows indicating movement and a depth of 24 inches and 6 inches.
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
Overflow Structure

Overflow elevation

24" Thread/cap underdrain (orifice option)

To storm drain or approved discharge point

Closed perforated pipes

Discharge at TGL elevation

with grout

(perforations)
Bioretention Edges

Separate facility from adjacent landscaping with wall or curb.

OK to slope soil mix against curb to reduce drop-off. And/or use plantings to discourage entry.

6" min. average depth

Soil mix

Gravel 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 irrigation or fertilization
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
### Construction

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

- 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

- Extension of standard 1-year warranty for landscaping
- Allows identification and correction of problems during rainy season
Using the Updated Central Coast SCM Sizing Calculator

Tony Dubin
Outline of Today’s Presentation

1. Describe function of SCM Sizing Calculator
2. Illustrate how Calculator can help with PCR compliance
   - Examples
   - What’s new

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**

### 1. Project Information

- **Project name:** Working test
- **Project location:** Working test
- **Tier 2/Tier 3/Tier 4:** Tier 3 - Retention
- **Design rainfall depth (in):** 2.4
- **Total project area (ft²):** 14000
  - **Total new impervious area (ft²):** 10000
  - **Total replaced impervious in a USA (ft²):** 0
  - **Total replaced impervious not in a USA (ft²):** 0
  - **Total pervious/landscape area (ft²):** 0

### 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>
<tbody>
<tr>
<td>DMA #6a</td>
<td>Drains to SCM</td>
<td>10000</td>
<td>Roof</td>
<td>New</td>
<td>SCM #1</td>
</tr>
<tr>
<td>DMA #7</td>
<td>Self-Treating</td>
<td>4000</td>
<td>Roof</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA #8</td>
<td>Drains to SCM</td>
<td>10000</td>
<td>Roof</td>
<td>Replaced</td>
<td>SCM #2</td>
</tr>
</tbody>
</table>

**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):** 0
- **Total pervious/landscape area (ft²):** 0

### 3. SCM Characterization

<table>
<thead>
<tr>
<th>Name</th>
<th>SCM Type</th>
<th>Safety Factor</th>
<th>SCM Soil Type</th>
<th>Infl. Rate (in/hr)</th>
<th>Area (ft²)</th>
<th>Flow Control</th>
<th>Reservoir</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>700</td>
<td>Yes</td>
<td>Depth (in)</td>
</tr>
<tr>
<td>SCM #2</td>
<td>Direct Infiltration</td>
<td>2</td>
<td>HSG C/D</td>
<td>0.25</td>
<td>700</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.

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

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

#### DMA #1
- **Type:** Self-Treating
- **Area:** 5000 ft²
- **Surface Type:** Grouted unit pavers
- **New, Replaced?:** New
- **Connection:** SCM #1

#### DMA #3
- **Type:** Drains to SCM
- **Area:** 4000 ft²
- **Surface Type:** Grouted unit pavers
- **New, Replaced?:** New

#### DMA - SRA #1
- **Type:** Self-Retaining
- **Area:** 4300 ft²
- **Surface Type:** Roof

#### Building Roof DMA
- **Type:** Drains to Self-Retaining
- **Area:** 2000 ft²
- **Surface Type:** Roof

**Select DMA types:**
1. Self-Treating
2. Self-Retaining
3. Drains to SCM
4. Drains to Self-Retaining

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

**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:**
### 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.

**Flow Control** | **Reservoir**
---|---
Orifice? | Depth (in)
No | 6
Yes | |
Launching Model and Viewing Results

4. Run SBUH Model

[Image of Launch Model button]

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

Yellow-shaded cells are copied from “Project Information” sheet
Blue-shaded cells contain results that are copied to the “Project Information” sheet

### SCM #1

<table>
<thead>
<tr>
<th>SBUH Parameters:</th>
<th>SCM Parameters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design rainfall depth (in) = 2.00</td>
<td>Plan area (ft²) = 800</td>
</tr>
<tr>
<td>Model time step (min) = 10</td>
<td>Sizing factor = 0.114</td>
</tr>
</tbody>
</table>

**DMA Summary**

- New impervious area: 7000 ft²
- Replaced impervious in USA: 0
- Replaced impervious not USA: 0
- Landscape area: 68
- Solid unit pavers set in sand: 89
- Non-runoff generating area: 4300

<table>
<thead>
<tr>
<th>Travel path length (ft)</th>
<th>Time of concentration (min)</th>
<th>(rain/runoff%)</th>
<th>(rain/runoff%)</th>
<th>(rain/runoff%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150.3</td>
<td>5.0</td>
<td>89%</td>
<td>10%</td>
<td>51%</td>
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</tbody>
</table>

### SBUH Runoff Calculations

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Distribution Type I</th>
<th>Rainfall Depth (in)</th>
<th>Cumulative Rainfall (in)</th>
<th>Instantaneous Runoff (in)</th>
<th>Cumulative Runoff Depth (in)</th>
<th>Instantaneous Runoff (in)</th>
<th>Instantaneous Runoff Rate (cfs)</th>
<th>Routed Flow Rate (cfs)</th>
<th>Bioretention Inflow (ft³)</th>
<th>Bioretention Stormwater</th>
<th>Bioretention Water Volume (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
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<td>0.0000</td>
</tr>
</tbody>
</table>

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>
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<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>
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</table>
## All DMAs Defined

### 2. DMA Characterization

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<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>
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<tr>
<td>1-RR</td>
<td>Drains to Self-Retaining</td>
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<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>
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<tr>
<td>1-FY-1</td>
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<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>
<tr>
<td>2-RF</td>
<td>Drains to SCM</td>
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<td>Roof</td>
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<td>Bioretention-1</td>
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<td>2-RR</td>
<td>Drains to Self-Retaining</td>
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<td>Roof</td>
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<tr>
<td>8-RF</td>
<td>Drains to SCM</td>
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<td>Bioretention-2</td>
</tr>
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<td>8-RR</td>
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<td>Roof</td>
<td>New</td>
<td>8-RY</td>
</tr>
<tr>
<td>8-DW</td>
<td>Drains to SCM</td>
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<td>Concrete or asphalt</td>
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</tr>
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<td>8-RY</td>
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<td>9-RF</td>
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</tr>
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<td>9-RR</td>
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<td>Roof</td>
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<td>Concrete or asphalt</td>
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<tr>
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<tr>
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<td>Concrete or asphalt</td>
<td>New</td>
<td>Bioretention-1</td>
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<td>Drains to SCM</td>
<td>10370</td>
<td>Concrete or asphalt</td>
<td>New</td>
<td>Bioretention-2</td>
</tr>
</tbody>
</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>Infiltration Rate (in/hr)</th>
<th>Area (ft²)</th>
<th>Flow Control</th>
<th>Reservoir Depth (in)</th>
</tr>
</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>
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<tr>
<td>Bioretention-2</td>
<td>Bioretention</td>
<td>1</td>
<td>HSG C/D</td>
<td>0.25</td>
<td>2700</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
Run Calculator SBUH Model

- Check self-retaining area ratios (<2:1)
- Calculate min. SCM storage volume
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>
</tr>
</thead>
<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

<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>Orifice?</th>
<th>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>
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<td>No</td>
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<tr>
<td>SCM-2</td>
<td>Bioretention</td>
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<td>HSG C/D</td>
<td>0.25</td>
<td>800</td>
<td>Yes</td>
<td>6</td>
</tr>
</tbody>
</table>

SCM volume reduction
Questions

- Move to demonstration
Central Coast SCM Sizing Calculator: A Look Under the Hood

Tony Dubin
Presentation Overview

1. Show how Calculator sets up and runs SBUH model

2. Show how interface work and how results are reported
User Interface

• Calculator limits input and format changes
  – Guards against deleting/modifying underlying equations
• Manually unlock if necessary
User Interface Demonstration

• Move to Calculator and show
  – Combo boxes
  – Add/Remove DMAs
  – Automatically disabling/enabling cells based on DMA Type value
  – VBA code
SCS, SBUH Equations Worksheet

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

<table>
<thead>
<tr>
<th>Step</th>
<th>Minute</th>
<th>Cumulative Distribution</th>
<th>Incremental Distribution</th>
</tr>
</thead>
<tbody>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
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<td>0.0027</td>
</tr>
<tr>
<td>2</td>
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</tbody>
</table>

Stormwater Runoff and Routing Equations:

Computing Runoff (SCS and SBUH are the same):

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

where:

$$ R = \text{runoff (in)} $$

$$ P = \text{rainfall (in)} $$

$$ I_a = \text{initial abstraction (in)} $$

$$ S = \text{potential maximum soil moisture retention after runoff begins (in)} $$

$$ CN = \text{runoff curve number} $$

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

$$ R = \frac{(P - 0.25S)^2}{P - 0.8S} $$

$$ I_a = 0.25 $$

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

SBUH Runoff Routing:

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

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

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

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

where:

$$ I_t = \text{instantaneous hydrograph (cfs)} $$

$$ R_t = \text{runoff for current time step (in)} $$

$$ A = \text{contributing area (ft)} $$

$$ dt = \text{calculation time step (min)} $$

$$ T_c = \text{time of concentration} $$

$$ n = \text{Manning's roughness (0.011 for pavement)} $$

$$ L = \text{flow length (ft; computed from tributary area)} $$

$$ s = 0.005 \text{ (ft/ft; assumed value)} $$

Note: set minimum $T_c = 5$ minutes (Portland BES recommendation)
SCS, SBUH Equations Worksheet

**SCS, SBUH Equations Worksheet**

- **Computing Runoff (SCS and SBUH are the same):**
  
  \[ R = \frac{(P - I_a)^2}{P - I_a + S} \]
  
  \[ I_a = 0.2S \]
  
  \[ R = \frac{(P - 0.2S)^2}{P - 0.8S} \]
  
  \[ S = \frac{1000}{CN} - 10 \]

- **SBUH Runoff Routing:**
  
  \[ I_t = \frac{R_t \times A}{dt} \times \frac{1}{12 \times 60} \]
  
  \[ Q_{t+1} = Q_t + w[I_t + I_{t+1} - 2Q_t] \]
  
  \[ w = \frac{dt}{(2T_c + dt)} \]
  
  \[ T_c = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} \times s^{0.4}} \]

- **Definitions:**
  
  - \( R \): runoff (in)
  - \( P \): rainfall (in)
  - \( I_a \): initial abstraction (in)
  - \( S \): potential maximum soil moisture retention after runoff begins (in)
  - \( CN \): runoff curve number
  
  - \( I_t \): 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
  - \( T_c \): time of concentration

- **Notes:**
  
  - \( n \): Manning's roughness (0.011 for pavement)
  - \( L \): flow length (ft; computed from tributary area)
  - \( P_2 \): 2-year, 24-hour rainfall (in)
  - \( s \): 0.005 (ft/ft; assumed value)
  
  - Note: set minimum \( T_c = 5 \) minutes (Portland BES recommendation)
### Information to and from SBUH Model

#### Yellow-shaded cells
- Copied from "Project Information" sheet

#### Blue-shaded cells
- Contains results copied to the "Project Information" sheet

#### SBUH Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Design rainfall depth (in)</td>
<td>2.00</td>
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<tr>
<td>Model time step (min)</td>
<td>10</td>
</tr>
<tr>
<td>DMA Summary</td>
<td></td>
</tr>
</tbody>
</table>
- New impervious area: 7000 ft²
- Replaced impervious in USA: 0
- Replaced impervious not USA: 0
- Landscape area: 68
- Solid unit pavers set in sand: 89
- Non-runoff generating area: 4300
| Travel path length (ft)            | 150.3   |
| Time of concentration (min)        | 5.0     |

#### SBUH Runoff Calculations

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Distribution (Type I)</th>
<th>Rainfall Depth (in)</th>
<th>Cumulative Rainfall (in)</th>
<th>Cumulative Runoff Depth (in)</th>
<th>Instantaneous Runoff (in)</th>
<th>Instantaneous Runoff Rate (cfs)</th>
<th>Routed Flow Rate (cfs)</th>
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</thead>
<tbody>
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<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

#### Bioretention Hydraulics

- 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
- Soil depth (ft): 2.0

#### Equations
- SBUH runoff and routing calculations
- Equations are visible to the user

#### Bioretention hydraulic calculations
- Bioretention water volume (ft³): 0.0000
### SBUH Model Demonstration

- **Move to Calculator and show**
  - Movement of values between Project Information sheet and SBUH Model sheet
  - Each SCM is represented by an instance of SBUH
  - Lookups, Constants worksheet
  - VBA code
Reporting Results

• “Launch Model” button needed to create or update results. Updates:
  - SCM Minimum Sizing Requirements table
  - Self-Retaining Area Checks table
• Model warns “Results are out of date” when DMAs or SCMs are updated
Model Reporting Demonstration

• Move to Calculator and show
  – SCM sizing results code
  – Self-retaining area checks code
Discussion

Cathleen Garnand