The Post-Construction Manual

Planning, Design, and Construction of Low Impact Development Features and Facilities
Workshop Objectives

• Improve the quality of applications for development project approvals
• Better use of Low Impact Development
• Timely and thoughtful integration of LID into site, landscape, and drainage design
Motivators

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

*You must do your own:*
- Enthusiasm
- Interest
- Energy

*To achieve:*
- Synergies
- Opportunities
- Elegance
Basics: What’s in the Manual
What’s in the Manual

Chapters
1. About the Requirements
2. Path to Compliance
3. Preparing a Stormwater Control Plan
4. Documenting Your LID Design
5. Preparing an Operation & Maintenance Plan
Resources

Post-Construction Manual with Appendices

- **A:** Source Control Checklist
- **B:** Bioretention Construction Checklist
- **C:** Stormwater Control Plan Template for Small Projects
- **D:** Stormwater Control Plan Template for Regulated Projects
- **E:** Bioretention Facility Plant Matrix

**Download from Countywide Program websites**

- Excel-based Calculator
- Example Stormwater Control Plans (2)
- Example Operation and Maintenance Plans (2)
- Operation and Maintenance Agreement Template
- Technical Criteria for Non-LID facilities
- Bioretention Facility Inspection Checklist
Basics: 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>Higher peak flows</td>
<td>Flooding and scouring of stream beds</td>
</tr>
<tr>
<td>Increased runoff volumes</td>
<td>Flash flows</td>
</tr>
<tr>
<td>Increased runoff durations</td>
<td>Discharge when runoff did not previously occur</td>
</tr>
<tr>
<td>Greater runoff energy</td>
<td>Stream erosion at moderate stream flow rates</td>
</tr>
<tr>
<td>Greater runoff energy</td>
<td>Higher pollutant loading</td>
</tr>
<tr>
<td>Decreased infiltration</td>
<td>Conveys trash and gross pollutants</td>
</tr>
<tr>
<td>Dry weather discharges</td>
<td>Lower and less frequent stream base flows</td>
</tr>
<tr>
<td>Dry weather discharges</td>
<td>High pollutant concentrations</td>
</tr>
</tbody>
</table>

**Diagram:**
- **Bankfull Stage**
- **Bankfull Width**
- **Present Flow**
- **Roots**
- **Valely Wall**
- **Silt and Debris**
- **Left Flood Plain**
- **Central Channel**
- **Right Flood Plain**

**Legend:**
- **Dashed Line:** Present Flow
- **Red Line:** Bankfull Width
- **Blue Line:** Root Line
### 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
Bioretention & Urban Landscape
Resilience
Resilience

RAIN GARDEN (BIORETENTION BASIN)

In rain gardens like this one, runoff flows the surface during storms, and then seeps through a planting mix of sand and compost. Plant roots help absorb runoff and break down some pollutants. Other pollutants are safely bound by compost. Sediment in the runoff is infiltrated into the ground beneath the rain garden, replenishing groundwater. During intense storms, excess filtered runoff seeps into a perforated pipe connected to the storm drain system.

Rain gardens also protect creeks by slowing runoff and reducing erosion flows. They prevent trash, spilled liquids, and wash water (like car washing) from entering creeks and storm drains during wet weather as well as during rainstorms. Rain gardens require thirty years or more with only routine maintenance of plants and landscaping—and occasional removal of trash and sediment near inlets.
Resilience
Basics: 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 from landscaped or natural areas
Drainage Management Areas
Drainage Management Areas

Natural

DMA-8

DMA-5

DMA-6

Paved

DMA-7

Landscaped

Landscaped

Landscaped
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
Roof and Grading Plans
Setting Up Calculations

• **Self-retaining Area**

<table>
<thead>
<tr>
<th>DMA Name</th>
<th>Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA-8</td>
<td>9350</td>
</tr>
</tbody>
</table>

• **Area Draining to Self-retaining Area**

<table>
<thead>
<tr>
<th>DMA</th>
<th>Square Feet</th>
<th>Surface</th>
<th>Runoff Factor</th>
<th>Receiving DMA</th>
<th>Receiving DMA Area</th>
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</thead>
<tbody>
<tr>
<td>DMA-1</td>
<td>1300</td>
<td>Roof</td>
<td>1.0</td>
<td>DMA-8</td>
<td>9350</td>
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</tbody>
</table>
### Setting Up Calculations

- **Areas Draining to Facilities**

<table>
<thead>
<tr>
<th>DMA</th>
<th>Area</th>
<th>Surface</th>
<th>Runoff Factor</th>
<th>Area × Runoff Factor</th>
<th>Sizing Factor</th>
<th>Facility Size</th>
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<tbody>
<tr>
<td>DMA-2</td>
<td>1050</td>
<td>Roof</td>
<td>1.0</td>
<td>1050</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA-4</td>
<td>1300</td>
<td>Roof</td>
<td>1.0</td>
<td>1300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA-7</td>
<td>7025</td>
<td>Paved</td>
<td>1.0</td>
<td>7025</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total |       |         | 9375         | 0.04                 | 375           |               |
Bioretention Footprint

<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>

Total area: 30645 square feet
Commercial Project SCP Example
Example Use of E.12 Calculator

Provision E.12 Sizing Calculator

See the instructions and the BASMAA Post-Construction Manual

<table>
<thead>
<tr>
<th>Step 1: Enter Total Site Area</th>
<th>27800</th>
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</table>

<table>
<thead>
<tr>
<th>DMA Name</th>
<th>Square Feet</th>
<th>Self-Treating</th>
<th>Self-Retaining</th>
<th>Runoff Factor</th>
<th>Total DMAs</th>
<th>Total Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA-1</td>
<td>2805</td>
<td></td>
<td>1</td>
<td>1</td>
<td>26734</td>
<td>1066</td>
</tr>
<tr>
<td>DMA-2</td>
<td>6130</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA-3</td>
<td>4680</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA-4</td>
<td>1770</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA-5</td>
<td>155</td>
<td></td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA-6</td>
<td>550</td>
<td></td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
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<tr>
<td>DMA-7</td>
<td>4275</td>
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<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA-8</td>
<td>6369</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Step 7: Enter Facility Footprints

- Footprint on Exhibit: 270, 331, 465
- Minimum Size: 186, 245, 459

Step 8: Iterate sizes of facility footprints and DMAs until all footprints are at least the minimum AND DMAs.

Step 9: Check to make sure Areas Draining to each Receiving Self-Retaining Area do not exceed maximum.

Step 10: Check results on this spreadsheet are consistent with what is shown on the SCP Exhibit.
Topic 1: Provision E.12 Applicability and Requirements
<table>
<thead>
<tr>
<th>Project Type</th>
<th>Impervious Area</th>
<th>Requirements</th>
<th>Submittal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Family</td>
<td>SF $\geq$ 2,500</td>
<td>At Least One Site Design Measure</td>
<td>Follow Small Projects template</td>
</tr>
<tr>
<td>Small</td>
<td>2,500 $\leq$ SF $\leq$ 5,000</td>
<td>Site Design + Bioretention</td>
<td>Follow manual and use template</td>
</tr>
<tr>
<td>Regulated</td>
<td>SF $\geq$ 5,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roads</td>
<td>SF $\geq$ 5,000*</td>
<td></td>
<td>Case-by-case</td>
</tr>
</tbody>
</table>
What to count toward threshold

• Count:
  – New impervious surface that is built on footprint of existing impervious surface

• Do not count:
  – Interior remodels
  – Routine maintenance or repair (including re-roofing)
  – Pavement resurfacing
  – Raised decks or surfaces that drain to sanitary
• Standard for Phase II municipalities is in Provision E.12.f.
  – Post-project runoff shall not exceed the estimated pre-project flow rate for the 2-year, 24-hour storm.

• A modeling study shows a bioretention facility designed according to the Manual criteria will meet this hydrologic standard.
Topic 2: E.12 Compliance for Small Projects
Using the Template
1. Complete Project Data Form

2. Delineate impervious areas and locations of runoff reduction measures
   - Disperse runoff to vegetated area
   - Pervious pavement
   - Cisterns or Rain Barrels
   - Bioretention Facility or Planter Box

3. Complete and submit your plan
Small Projects Options

• Option 1: Disperse runoff from roofs or pavement to vegetated areas
  – Direct downspout to landscaping or
  – Sheet flow from pavement to landscaping
  – Maximum 2 SF impervious to 1 SF pervious
  – Reasonable expectation an inch of rainfall will produce no runoff
Small Projects Options

- Option 2: Use pervious pavement
  - Meet design criteria (same as for Regulated Projects)
  - Path or walkway
Small Projects

- Simple sketch is all that’s required
- Delineate areas and show approximate square footage
Topic 3: LID and the Development Review Process
Conditions/Mitigation Measures

- 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.
Submittal for Entitlements

- Show LID features and facilities on:
  - Site Plan
  - Landscape Plan
  - Preliminary Grading and Drainage Plan
Bioretention Facilities Locations

- 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
Don’t create pits
Don’t create pits
Optimal size for bioretention?

½ Acre

4%

30 ft
Small Shopping Center
• Drain a portion of each roof to yard
• Drain driveways to street
• Drain street to bioretention facilities on commonly owned parcels
Exceptions to Bioretention

• An acre or less of impervious area
  – Designated pedestrian oriented district
  – 85% of project site covered by structures

• Facilities receiving runoff only from pre-project impervious areas

• Historic sites, structures, or landscapes
Topic 4. Self-Treating and Self-Retaining Areas
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
Areas draining to self-retaining
Topic 5. Bioretention Design Criteria
Bioretention Design Criteria

Figure 4-5. Bioretention Facility
Cross-section
Not to Scale

- Curb cut, or drop inlet if needed to ensure runoff capture
- 4” min. SDR 35 or equivalent sweep bend and cleanout
- Specified soil mix
- 3” max. mulch if specified
- 6” ponding
- Concrete drop inlet or manhole with frame. Anthem or beehive grate preferred; ¼” openings
- Freeboard if needed to manage overflows
- Walls establish consistent rim elevation around perimeter
- To storm drain or approved discharge point
- Vertical moisture barrier if needed to protect pavement or structures
- Class 2 permeable Caltrans specification 68-2.02(3)
- 4” min. SDR 35 or equivalent, perforations facing down. Lay in groove in top of gravel.
- Native soil, no compaction. Rip to loosen.
- Schedule 80 (no perforations) Seal penetration with grout.

Notes:
- No liner, no filter fabric, no landscape cloth.
- Maintain BGL, TGL, TSL throughout facility area at elevations to be specified on drawing.
- Elevation of perforated pipe underdrain is atop gravel layer.
- See text for soil mix specification, planting and irrigation guidance.
Edge Treatments

Separate facility from adjacent landscaping with curb.

OK to slope sand/compost mix against curb to reduce drop-off. And/or use plants to discourage entry.
• Bioretention facilities are level so they “fill up like a bathtub.”
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
Call out elevations

- Outlet structure
  - Overflow grate
  - Underdrain connection
- Soil layers
  - Top of soil layer
  - Bottom of soil layer
  - Bottom of gravel layer
Foundations and Pavement
Plants that work

<table>
<thead>
<tr>
<th>Plant Categories</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses and Grass-like Plants</td>
<td>Grass refer to those species that are monocotyledonous plants with slender-leaved herbage.</td>
</tr>
<tr>
<td>Herbaceous Perennials and Groundcovers</td>
<td>Herbaceous refers to those species with soft upper growth rather than woody growth. Some species will die back to the roots at the end of the growing season and grow again at the start of the next season. This list only includes those that are perennial, i.e. live for several years.</td>
</tr>
<tr>
<td>Shrubs</td>
<td>Shrub is a horticultural distinction that refers to those species of woody plants which are distinguished from trees by their multiple stems and lower height. A large number of plants can be either shrubs or trees, depending on the growing conditions they experience.</td>
</tr>
<tr>
<td>Small Tree</td>
<td>Small trees refers to those species of woody plants with one main trunk and a maximum size of 25' tall and wide.</td>
</tr>
<tr>
<td>Tree</td>
<td>Tree refers to those species of woody plants with one main trunk and a rather distinct and elevated head with a size greater than 25' tall or wide.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Preference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Preference-Low/Moderate/High</td>
<td>We have provided recommendations for irrigation. All plants should be watered with more frequency during the first two years after planting. After this establishment period, Low water use plants will only need supplemental irrigation at the hottest and driest sites. Plants with Moderate irrigation needs will be best with occasional supplemental water (once per week to once per month) and plants with High irrigation needs will be best with more frequent watering especially during periods of drought in the cooler seasons.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Preference-Summer Irrigation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plants with a check in this column will not withstand a long period of summer drought without irrigation. Plants with an 'ok' in this column are tolerant of, but do not require, frequent summer irrigation. Plants with nothing in this column may not tolerate summer irrigation after establishment.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stress Tolerance</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tolerates Heat</td>
<td>A check in the heat column indicates that the plant will tolerate hot sites. It should not be confused with a plants preference for sun. Absence of the check indicates it should only be used in areas close to the Bay or other cool sites.</td>
</tr>
<tr>
<td>Tolerates Coast</td>
<td>The coast column indicates plants that perform well within 1,000 feet of the ocean or bay. Most of these plants tolerate some amount of salt air, fog, and wind.</td>
</tr>
<tr>
<td>Tolerates Wind</td>
<td>A check in the wind column means that the plant will tolerate winds of ten miles per hour or more.</td>
</tr>
<tr>
<td>Zone 1</td>
<td>Plants that tolerate Zone 1 are common riparian, wetland and bog plants capable of surviving in</td>
</tr>
</tbody>
</table>
Avoid design conflicts

- Elevations consistent with grading and architectural plans
- Facilities do not interfere with parking or pedestrian circulation
- Utilities are located elsewhere
Topic 6.
Bioretention Construction
Construction Checklist

• 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
Topic 7. Bioretention Operation and Maintenance
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
Wrap Up