The Central Coast Low Impact Development Initiative (LIDI):
Development of Bioretention Standard Details and Technical Specifications

Project Purpose

Bioretention, or the use of plants and soil to infiltrate, slow and clean stormwater, is one of the most commonly used structural LID stormwater control measures because it is relatively inexpensive and can be combined with other project requirements (e.g., landscaping). Although there are several statewide and regional LID documents that include bioretention guidance, many lack sufficient technical detail to support the design and proper construction of functioning bioretention facilities. Also, technical design guidance provided by several California, Oregon, and Washington sources is often inconsistent and in some cases, technically incorrect. The purpose of the LIDI project was to create a set of standard details and technical specifications that incorporate the most current knowledge of bioretention design.[1] Although this effort originated in the Central Coast region, the project deliverables can be used for bioretention design by others in California, as appropriate to their region and regulatory requirements.

Project Scope

There are several bioretention design types, including different edge conditions. Ideally, an LID designer would have access to standard details and technical specifications for each bioretention type. As an initial effort, LIDI focused on the applications most commonly encountered by designers, which tend to include:

1. Bioretention with a street edge condition
2. Bioretention with a sidewalk edge condition
3. Bioretention with a parking lot edge condition

Furthermore, for each of these edge conditions, the following variations were developed:

a. Without underdrain
b. With underdrain
c. Without on-street parking
d. With on-street parking
e. With flat/planter facility design
f. With sloped-sided facility design

For these biorentention types, technical specifications were provided and grouped to include:

1. Facility design/dimensions (widths, depths, and slopes)
2. Hard infrastructure (inlet curb cut, sidewalk edge infrastructure, and check dams)
3. Facility media (soil, aggregate, and mulch)
4. Landscape (planting and irrigation)
5. Underdrain design (design modifications when underdrain is included)

The bioretention technical guidance is provided as standard detail drawings that include design and construction notes, and supporting documentation (the technical specifications) that provides additional information too lengthy to include in the drawings. The work is available in the native file format (e.g.,

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[1] In general, standard details and technical specifications are two key resources that, when combined, provide clear guidance for successful design and construction of built elements. *Details* are an illustration of the physical dimensions and elements that make up the facility being constructed, and *technical specifications* are a summary, in written form, of the physical elements shown in the details, plus any additional supporting information. In some cases, specifications may include performance standards in addition to physical design guidelines

AutoCAD DWG) so that users, such as municipalities, can modify the drawings to include their own logos and code references, and designers can insert them into their project detail sheets. The files will be available on both the Central Coast LID Initiative and California Stormwater Quality Association (CASQA) websites (centralcoastlidi.org and casqa.org).

Development of Updated Bioretention Details and Specifications: The Process

The following process was used to develop the bioretention standard details and technical specifications:

1. *Review of existing bioretention technical guidance for similarities and inconsistencies*. Technical guidance documents and specifications were selected from throughout California, Washington, and Oregon. The documents reviewed are listed in Attachment 1.

2. *Consultation with experienced LID practitioners to identify improvements to existing design guidance.* LIDI sought the assistance of West Coast (California, Oregon, and Washington) experts in the field of bioretention[2]. The range of geographic experience among the consulted practitioners allowed for a robust discussion of various bioretention factors, including climate, regulatory requirements, and implementation success and failure. Technical consensus was not always achieved among the experts especially on design elements with insufficient data related to long-term performance. In situations where there was varying technical opinion among the group, LIDI used best judgment to determine the final design detail or specification. A summary of key discussion topics and the associated decisions is provided in Attachment 2. Also included in Attachment 2 are items identified as needing additional research or data to improve bioretention design guidance.

3. *Incorporation of technical expertise into a new set of bioretention standard details and technical specifications.* Materials were provided to the CASQA's Best Management Practice (BMP) Subcommittee for additional review and input.

4. *Placement of the new bioretention standard details and technical specifications on the LIDI and CASQA websites (centralcoastlidi.org and casqa.org).* At these websites, the details and specifications can be accessed in both PDF and native file format, free of charge.

Next Steps

The bioretention design resources completed for this project provide a basic foundation for designs that include commonly encountered edge conditions (street, parking lot, and sidewalk) and options for using an underdrain. Recognizing that bioretention designs can be applied to many different layouts, in 2013 LIDI intends to develop additional plan view drawings to illustrate options for incorporating bioretention into a variety of situations, such as:

- curb bulb extensions (plan view for right-of-way application),
- bioretention planters (plan view for right-of-way application), and
- bioretention areas (plan view for parking lot application

LIDI will also pursue improved and updated designs for select bioretention component details that were identified as desired technical specifications, such as alternate check dam designs, orifice structures, "on/off" designs for underdrains, and additional overflow structure options.

[2] Daniel Apt, RBF Consulting; Wayne Carlson, AHBL; Dan Cloak, Dan Cloak Environmental Consulting; Darla Inglis, Low Impact Development Initiative; Melanie Mills, Low Impact Development Initiative; Kevin Robert Perry, Urban Rain Design. Cathleen Garnand with County of Santa Barbara graciously provided municipal perspective review and input.

Attachment 1

Stormwater Manuals and Technical Guidance Documents Reviewed for the LIDI Bioretention Standard Details and Technical Specifications Project

City of Los Angeles Development Best Management Practices Handbook (Low Impact Development Manual), Part B Planning Activities, 4th Edition, June 2011

City of Los Angeles, Bureau of Engineering, Standard Plans

City of Portland Stormwater Management Manual, Chapter 2: Facility Design, Revision 4, August, 2008

City of Santa Barbara Storm Water BMP Guidance Manual (Technical Guidance Manual for Post-Construction Storm Water Management), July 2008

City of Seattle Stormwater Manual, Volume 3 (Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual), November 2009

Contra Costa Clean Water Program Stormwater C.3 Guidebook (Stormwater Quality Requirements for Development Applications), 6th Edition, February 2012

LID Technical Manual for Puget Sound, draft 2012 version

Low Impact Development Manual for Southern California: Technical Guidance and Site Planning Strategies, April 2010

Riverside County Flow Control Water Conservation District Design Handbook for Low Impact Development Best Management Practices, September 2011

Attachment 2

Summary of Select Items Reviewed during Development of the Bioretention Standard Details and Technical Specifications

This attachment documents bioretention design issues that were addressed as part of the process for developing standard details and technical specifications. Additionally, this attachment identifies design elements on which further data or research is needed.

1. **Use of an underdrain**
   a. The depth of bioretention soil media (BSM) is often specified to be at least 18 inches in a facility with an underdrain. The final design specification recommends a minimum of 24 inches of BSM to improve the pollutant removal function of the facility. Supporting data included the following:
      i. Research (Li et al. 2009) suggests that higher-volume bioretention cells (i.e., with deeper soil media) perform better at reducing peak flow rates and underdrain discharge volumes.
      ii. Where dissolved phosphorus is a concern, increased soil media depth (minimum 24 inches) is recommended to separate the top of the aggregate layer and the top of the soil media enough to avoid leaching of sequestered phosphorus (Hunt et al. 2011).

2. **Structural integrity of curbs and gutters**
   a. The curb and gutter detail provided shows a 24-inch-deep curb and a 24-inch-wide gutter. Geotechnical professionals with LID experience recommended this more substantial curb depth and gutter width. This detail is intended to provide additional structural support at the road/bioretention area interface, especially in areas of potentially expanding clay soils and where vehicles will repeatedly push against curbs. Notes allow for the project civil/geotechnical engineer to adjust this detail when appropriate.

3. **Structural integrity of adjacent conditions, such as sidewalks, streets, and parking lots**
   a. The details call for maintaining a 6-inch-wide “bench” of native soil along the sides of a bioretention facility to provide additional support for adjacent conditions. Although beneficial in both new and retrofit projects, maintaining a bench is particularly important in

retrofit projects where excavation could undermine and damage existing sidewalks.

4. **Specification of storage area aggregate between aggregate and BSM**
    a. The aggregate layer stores additional stormwater when the native soil layer cannot infiltrate the desired volume. The aggregate specification indicates the optimal void space for maintaining structural integrity. The need to prevent the overlying BSM from migrating downward into the aggregate layer informs the use of an aggregate filter layer (also see "Use of filter fabrics," below).
        i. Caltrans Class 2 Permeable meets aggregate performance objectives and includes a fine aggregate to keep overlying BSM fines from migrating into aggregate layer voids. No filter layer is needed with Caltrans Class 2 Permeable.
        ii. The term "washed rock" was removed from the aggregate specification because Caltrans Class 2 Permeable does not need to be washed to meet performance requirements. Also, specifying a "washed" aggregate may result in an unnecessary increase in material costs.
        iii. Local and regional availability of Caltrans Class 2 Permeable may be unreliable. Caltrans Class 3 Permeable aggregate serves as a substitute; however, it does not contain the finer aggregate and must be accompanied by an overlying filter layer. The filter layer used above Caltrans Class 3 Permeable aggregate is a 3-inch-deep layer of ¾-inch (No. 4) open-graded aggregate.

5. **Use of filter fabrics**
    a. Filter fabrics have historically been used between bioretention soil media and aggregate layers. The intent is to create a barrier to downward migration of soil fines into aggregate void spaces. Discussion among reviewers concluded that too often use of a filter fabric is associated with facility clogging. The preferred approach, when a filter layer is needed over Caltrans Class 3 Permeable aggregate (see 4 a. ii above) is to provide a 3" deep layer of ¾" (No. 4) open-graded aggregate.

6. **Compaction of BSM**
    a. Because BSM contains a high percentage of compost (30%–40% by volume), compacting precisely to 85%–90%, as often specified in plans and details, is not possible. In addition, attempts to compact BSM may inadvertently result in over-compaction and facility failure. Consequently, rather than provide a compaction

percentage (e.g., 85%–90%), it is better to describe an appropriate method for proper BSM placement and compaction.

b. The recommended approach for BSM installation is as follows: place BSM in 6-inch lifts; compact each lift with a landscape roller or by lightly wetting; and allow BSM to dry overnight before planting.

7. **Drawdown time**
    a. Drawdown time relates to vector control (specific to location), soil and plant health, and public perception of safety. The technical specifications allow for a maximum standing water duration of 72 hours; however, drawdown time is ultimately determined by a local municipality or vector control agency.

Items Requiring Further Research

Listed below are bioretention design elements identified by the LIDI technical team as needing further research.

1. **Location of the underdrain relative to the aggregate layer**
    a. Some design details originating in the Pacific Northwest show a minimum 12-inch depth of aggregate cover over the underdrain. The origin of this element could not be identified during the LIDI review period. Further research is needed to determine if this design element was passed down from early designs (perhaps without performance justification), if it was developed in response to concerns about potential phosphorus leaching, or if there is another driver. Twelve inches of aggregate represents a significant material and installation expense, and a better understanding of underdrain placement is warranted.

2. **Minimum bottom width of sloped-sided facilities**
    a. The standard details include a 2-foot minimum bottom width for sloped-sided facilities. This minimum width is thought to reduce longitudinal channelization, but this performance attribute could not be confirmed. The inclusion of a 2-foot minimum bottom width may result in the overall facility being too wide for some common applications, such as replacing street parking in a curb bulb extension. More research is needed to understand the function, if any, of a minimum bottom width for sloped-sided facilities.

3. **Bioretention plant lists**
    a. Additional guidance is needed to provide technical design options for bioretention vegetation, such as appropriate plantings for reduced maintenance/water installations, more showy plant palettes

that include more nonnative options, and suitable plant palettes for extreme conditions (e.g., arid climates).

4. **Soil/plant health and performance**
    a. Concerns and questions are frequently raised regarding the long-term function of bioretention soils and the maintenance required to support performance. Further research into performance and maintenance is needed, especially concerning the following:
        i. The need to replenish the organic matter in the BSM
        ii. Actions needed to maintain long-term BSM structure and performance (e.g., soil replacement, use of biological amendments such as worms, and plant selection)
        iii. The pollutant removal attributes of the BSM and plants

<u>References</u>

Hunt, W. F., A. Davis, and R. Traver. 2011. "Meeting Hydrologic and Water Quality Goals through Targeted Bioretention Design." *Journal of Environmental Engineering*, October. American Society of Civil Engineers.

Li et al. 2009. "Water Quality Improvement through Reductions of Pollutant Loads Using Bioretention." *Journal of Environmental Engineering*, August. American Society of Civil Engineers.